



Department of Energy

ROCKY FLATS OFFICE
P.O. BOX 928
GOLDEN, COLORADO 80402-0928

ADMIN RECORD

95-DOE-08047

JAN 19 1995

Mr. Martin Hestmark
U. S. Environmental Protection Agency, Region VIII
ATTN: Rocky Flats Project Manager, 8HWM-RI
999 18th Street, Suite 500, 8WM-C
Denver, Colorado 80202-2405

Mr. Joe Schieffelin, Unit Leader
Hazardous Waste Facilities
Colorado Department of Public Health and the Environment
4300 Cherry Creek Drive South
Denver, Colorado 80222-1530

Gentlemen:

The Department of Energy (DOE), received your disapproval letter on January 5, 1995, and formally invokes Part 16 of the Interagency Agreement (IAG) to dispute the Environmental Protection Agency (EPA) and Colorado Department of Public Health and Environment (CDPHE) position on disapproval of the document "Technical Memorandum 4 - Human Health Risk Assessment Chemicals of Concern Identification-Operable Unit 3." This letter, with 5 enclosures, defines the nature of the dispute, the DOE's position on the dispute and the information relied upon to support this dispute.

The EPA and CDPHE disapproved Technical Memorandum (TM) No. 4 and rejected the human health contaminants of concern (COC) selected, and substituted EPA derived COCs to be used in the Operable Unit (OU) No. 3 Remedial Investigation Baseline Risk Assessment. Information on EPA's COC selection method, received with informal comments, was not sufficiently detailed to assess differences between the two methods (informal comments and EPA COC selection methodology in Enclosure 3). The stated basis for disapproval is "DOE's selection of COCs for OU 3 did not follow existing EPA guidance nor the methodology established for Rocky Flats.... We believe DOE inappropriately eliminated chemicals from further consideration in the baseline risk assessment."

The DOE is disappointed and puzzled by the disapproval and resulting agency comments. From the inception of the OU 3 Project, it was recognized by all parties to the IAG that OU 3 represents different conditions and circumstances than the rest of the site and deviations from the Rocky Flats COC selection methodology are warranted. As the issue of methodology appears to be the reason for disapproval; an outline of the alleged deviations with a short response to the alleged deviations is found in Enclosure 1. A more detailed response to all EPA/CDPHE comments is found in Enclosure 2. Enclosures 3 through 5 are referenced in Enclosure 1.

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A-OU03-000430

M. Hestmark & J. Schieffelin
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Disapproval of TM 4 again raises the question of the utility of the current consultative process. Specifically for OU 3, we met several times, the EPA provided written guidance which we followed (enclosed) and we actively pursued an open effective consultative process. The DOE feels strongly that TM 4 accurately follows the agreed methodology and accurately states the technical conclusions of the agreed COC selection process. By invoking the dispute process we invite a rational discussion on the technical merits of TM 4. If the dispute is limited to the technical merits of the document, we feel confident that all parties will reach a mutually satisfactory resolution.

Following resolution of this dispute, the DOE will request a schedule extension. TM 4 was submitted September 23, 1994, one month ahead of the IAG schedule. This is in keeping with DOE's commitment to not only comply with the IAG schedule, but also accelerate it wherever possible. In spite of committing to a fifteen day review period, the EPA and CDPHE spent over three months reviewing this document. During this three-month time period, the DOE formally requested comments on November 10, 1994, and December 9, 1994. The EPA and CDPHE did not respond to these requests. All parties must be held equally accountable for the commitments of this project. The DOE will request a day for day schedule extension from the time the comments were due, inclusive of the time required to resolve the dispute.

I will contact you to arrange the dispute meeting. If you have any questions, please call me at 966-4839.

Sincerely,


Steven W. Slaten
IAG Project Coordinator
Environmental Restoration

Enclosures

cc w/o Enclosures:

C. Gesalman, EM-453, HQ
K. Klein, OOM, RFFO
J. Roberson, AMER, RFFO
D. Brockman, AMESH, RFFO
F. Lockhart, ER, RFFO
B. Birk, ER, RFFO
S. Slaten, ER, RFFO
G. Hill, EGD, RFFO
M. Guillaume, SAIC
R. Stupka, SAIC
S. Stiger, EG&G
M. Buddy, EG&G

Enclosure 1

Outline of Alleged Methodology Deviations and Short Response

EPA ALLEGED METHODOLOGY DEVIATIONS AND OUTLINE OF DOE RESPONSE

The DOE believes the limitations of the approved Rocky Flats COC selection process were discussed with the regulators, and technically sound alternatives were presented in meetings and in TM 4. Since there were some uncertainties about the COC selection process during the stop work order, OU 3 consultation meetings were held with all parties. The DOE, EPA, and CDPHE met on three separate occasions (February 14, 1994, March 10, 1994, and May 3, 1994), not just on March 10, 1994, as indicated in the agency TM 4 comments (see Enclosure 4 for meeting minutes and agreements reached). Clearly the consultative process has broken down. Rationale for disputing the EPA/CDPHE position is based on the agreements reached, guidance given during the consultative process and technically sound arguments presented in TM 4.

Much of the development of TM 4 was done in consultation with the regulatory agencies and remains faithful to the jointly developed assessment methodology agreed to on March 30, 1994. This process employs the methodology developed by Dr. Richard Gilbert of Battelle, Pacific Northwest Laboratories and requires rigorous statistical analyses which use comparable background data sets (Gilbert, 1993). The OU 3 Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation (RFI/RI) field investigation program, designed in 1991 and approved by EPA and CDPHE in 1992, was originally intended to provide a one-to-one Upper Tolerance Limit (UTL) comparison of newly collected concentration data to background concentration data. It was not designed to support the rigorous statistical analyses of the Gilbert Methodology developed during the stop work order. Recognizing the limitations of the Gilbert methodology during development of TM 4, an iterative, consultative process was pursued with EPA and CDPHE to solve this problem. At the three previously mentioned meetings with EPA and CDPHE an alternative methodology was developed and implemented in conjunction with Gilbert for OU 3. Agreements were reached with the agencies and work proceeded based on these agreements.

The statistical tests employed by the Gilbert methodology require appropriately comparable data sets for both background samples and OU 3 investigative samples. It was determined that available background data sets were not representative of conditions found in OU 3, and that some of the OU 3 data did not meet the underlying assumptions of the Gilbert Methodology; such as comparison of the Rocky Flats background geochemical data with large offsite reservoirs.

On March 10, 1994, DOE agreed to go through the rigorous statistical tests for stream sediments (Gilbert) and use a Weight of Evidence (WOE) evaluation and professional judgment (also part of the Gilbert statistical evaluation) for the reservoir sediments. This agreement was formalized with a letter from EPA dated March 24, 1994 (see Enclosure 4). The statistical tests were conducted and results presented at the May 3, 1994, meeting.

At the May 3, 1994, meeting, the DOE presented specifics on the WOE approach that would be followed and which media it would be applied to. Discussions were held at this meeting regarding what the emphasis and priorities should be for OU 3. The issue of concern was the potential for background concentrations of metals such as arsenic and beryllium to become the risk drivers for OU 3, thereby changing the focus from radionuclide contamination. Naturally occurring elements derived from common rock forming minerals should not be the focus of the risk assessment.

The May 3, 1994, presentation showed why the Gilbert statistical evaluations for ground water, stream and reservoir surface waters, and reservoir sediments were not appropriate. Sound technical arguments for performing WOE evaluations for these media were also

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presented. Some of these arguments included a discussion of the Gilbert statistical evaluation results for stream sediments. Results of this evaluation identified 20 out of 26 metals as potential COCs based mainly on the Gehan test component of the Gilbert Methodology. It was determined that these results were caused by limitations of the compared data sets and we recommended the weight of evidence evaluation for the stream sediments as well. The results of the Gilbert statistical evaluation of stream sediments were not presented in TM 4.

The conclusions from the May 3, 1994, meeting were as follows:

- The WOE approach requires a significant level of effort. It was stressed that the main concern for OU 3 is plutonium and americium.
- EPA stated that ground water was not considered a complete pathway requiring evaluation in the Human Health Risk Assessment and that a comparison to UTLs was acceptable. DOE agreed to confirm that there was not a problem with the ground water. This issue was confirmed and will be discussed in the RFI/RI Report.
- Susan Griffin of EPA suggested that we may be able to reduce the effort by excluding chemicals with maximum concentrations below the Preliminary Remediation Goals (PRGs) (since the weight of evidence approach did require a significant level of effort.)

Additionally, the EPA and CDPHE committed to discuss the approach for metals with their internal resources and provide input to DOE by May 10, 1994. No input from EPA or CDPHE was ever received. However, in order to meet our IAG schedule commitments, the COC selection process proceeded without additional input.

Given the above historical development of the OU 3 COC selection process, the specific methodology deviations are now addressed. Agency rejection of TM 4 is based on what are perceived to be deviations from the approved methodology. Specifically, the EPA and CDPHE cite the following five deviations:

- 1) excluding Standley Lake and Mower Reservoir subsurface sediments from the COC selection process;

The EPA and CDPHE's contention that the exclusion of subsurface sediments from the evaluation represents a deviation from the approved process does not take into consideration that guidance was given by EPA and CDPHE on February 14, 1994 to forego a comparison to background data if there is not a completed exposure pathway for subsurface sediments (see Enclosure 4 for meeting agreements). The agencies contention also does not recognize that there was uncertainty regarding potential exposure pathways for Great Western Reservoir subsurface sediments and that these sediments are included in the TM 4 evaluation.

- 2) conducting the weight of evidence evaluation at the end of the process instead of the beginning;

The agencies contend that by conducting the WOE evaluation at the end of the COC selection process instead of the beginning, we deviated from the approved process. The March 24, 1994, EPA letter provides the basis for adding a WOE evaluation to the COC selection process. The agencies did not dictate where in the selection process this evaluation might be conducted. We elected to conduct the WOE evaluation at the end of the

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process for two reasons: 1) conducting the WOE evaluation at the end of the process is a more conservative approach, since the metals and radionuclides are taken through all of the risk screens first, indicating which potential contaminants of concern (PCOCs) contribute to risk; and 2) concentrating on PCOCs that are risk contributors reduced the level of effort spent on metals that are not of concern from a human health perspective. In addition, when the WOE evaluation is applied first as was done in the CDPHE Letter Report, the chemicals remaining as risk drivers in the "Areas of Concern" are the same as those identified in TM 4. Thus, location of WOE in the methodology does not change the conclusions. If as you contend, the process was "manipulated", then it was done by agreement of the three agencies. The DOE has a right to expect that commitments made during consultation will be followed.

3) not retaining chemicals with maximum concentrations above the Preliminary Remediation Goals ;

In fact, we retained these chemicals as PCOCs; however, when evaluated using WOE, it was determined that they were not COCs because concentrations/activities were consistent with background and benchmark levels, and did not warrant further evaluation.

4) not applying the "Gilbert Methodology" for stream surface water, stream sediment, and ground water;

This contention does not take into consideration that on May 3, 1994, the EPA, CDPHE and DOE agreed that ground water was not considered an exposure pathway and received a presentation on the inappropriate comparisons between data from the Geological Characterization Report and OU 3 stream surface water and stream sediment data. The EPA also fails to recognize that it is dubious whether the results of this methodology adequately represent site conditions due to uncertainties introduced by inappropriate data sets for these media, and that this fact was presented to the agencies on May 3, 1994.

In the EPA letter of March 24, 1994 recommending the use of the WOE methodology, the EPA stated " In fact, we believe that if DOE were to use Dr. Gilbert's approach, the conclusions would be less supportable than a weight of evidence approach". Yet in the EPA/CDPHE comments on TM 4 they state " We believe the background geochemical characterization data set is comparable and that it is possible that a statistical comparison can be conducted for these media although the power of the test may not be optimal." TM 4 was developed with the understanding that EPA and CDPHE supported the WOE approach. This change in position on the WOE approach after the results are in is unexpected and disconcerting.

5) applying the COC selection process by individual Hazardous Substance Site (IHSS) instead of by OU.

The agencies point out that the COC selection process was applied on an IHSS specific basis instead of an OU specific basis. While this is true, the agencies fail to recognize the limitations of the agreed upon process when applied to OU 3. OU 3 consists of four separate, very large IHSSs. IHSSs 200 (Great Western Reservoir), 201 (Standley Lake), and 202 (Mower Reservoir), are all water bodies separated by large expanses of land, with different influent sources, and different future land uses. It makes technical sense to evaluate the three reservoirs separately because they represent discrete exposure units. Combining all IHSSs by medium, would indicate plutonium as a COC in sediment for Standley Lake and Mower Reservoir, despite the fact that the maximum values for plutonium in Standley Lake and Mower Reservoir surface sediments are 0.553 picocuries per gram (pCi/g) and 0.488 pCi/g, respectively. These values are an order of magnitude

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below the residential PRG of 3.43 pCi/g. Additionally, because these sediments will remain under water, there is no exposure pathway available. The DOE would inappropriately assess Standley Lake and Mower Reservoir sediments through the risk assessment process and further obscure the actual risk for OU 3 and the public.

Identifying COCs on an IHSS specific basis is also consistent with the OU 3 Work Plan. The list of chemicals analyzed for each IHSS was different between IHSS's. For example, tritium was only analyzed in the Great Western Reservoir drainage and organics were only analyzed in the Mower Reservoir drainage. To apply a single list of COCs for the entire OU 3 is not technically appropriate. We view this approach as conservative.

Enclosure 2

Responses to EPA's Review on the COCs Identification TM 4

**RESPONSES TO EPA REGION VIII REVIEW COMMENTS ON THE
IDENTIFICATION OF CHEMICALS OF CONCERN
TECHNICAL MEMORANDUM NO. 4 (SEPTEMBER 23, 1994)**

January 18, 1995

These detailed responses are supplied for the purpose of addressing the Environmental Protection Agency's formal comments regarding Identification of Chemicals of Concern Technical Memorandum No. 4 (TM 4), dated September 23, 1994 (DOE, 1994a). EPA's Comments on TM 4 are in **BOLD** and are preceded by "Comment." DOE's responses to the comments are preceded by "Response to Comment."

GENERAL COMMENTS

EPA Noted the following deviations from the standard process for selecting contaminants of concern:

Comment 1, Section 2, Page 27. All data collected under the operable unit 3 (OU 3) field sampling program should be considered when selecting contaminants of concern (COCs). Potential exposure pathways should not be used to limit the data sets under consideration. Subsurface sediments in Standley Lake and Mower Reservoir were excluded incorrectly in DOE's analysis.

Response to Comment 1: All chemical and radiochemical data collected under the OU 3 field sampling program, as well as supplemental radionuclide data (e.g., Jefferson County soils and Great Western Reservoir sediments), were considered initially as the candidate population of data for selection of COCs. No analytical data were disregarded. On February 14, 1994, all parties (including EPA, CDPHE, and DOE) agreed that if sediment core data are not associated with an exposure pathway, the data do not need to be compared to background data for the risk assessment. Therefore, subsurface sediments in Great Western Reservoir were included in the COC identification process because of the possibility (though unlikely) that the reservoir may be drained and could be converted to residential, recreational, or commercial/industrial land uses. The probability of Standley Lake and Mower Reservoir being drained is considered remote. On this basis, subsurface sediments were considered part of the exposure pathway for Great Western Reservoir, but not for Standley Lake and Mower Reservoir. The nature and extent section of the RFI/RI report will present all analytical data regardless of whether the media is of concern in the Human Health Risk Assessment (HHRA).

By including subsurface reservoir sediments in the HHRA process at all, DOE has erred on the side of safety. This is because, in addition to a low likelihood of the reservoir being drained and zoned to allow human contact, it is very unlikely that subsurface contamination would ever be expressed at the concentrations observed in the sediment borings. Any construction activity necessary for development (e.g., clearing, grading, site preparation, excavation, etc.) would remove or extensively homogenize the comparatively small mass of subsurface material so that it would be indistinguishable from background.

All other data sets, with the exception of subsurface soils, were evaluated in TM 4. Surface soil in IHSS 199, surface sediments and surface water in IHSSs 200-202, and groundwater were included in the COC identification process.

Comment 2, Section 3, Page 1. The COC selection process as described on this page and illustrated in Figure 3-1 deviates from the process accepted by EPA, CDPHE, and DOE in three ways:

Response to Comment 2: As a result of technical inconsistency with the assumptions that underlie the approved process (DOE, 1993a; EPA, 1993; Gilbert, 1993) an alternative approach was used for comparing site data to background data. The alternative approach is referred to as the "weight-of-evidence (WOE) evaluation," since it relies on a series of data evaluation steps and involves the use of professional scientific judgement. The WOE evaluation involves the application of a variety of data analysis techniques in lieu of the formal, quantitative statistical tests recommended by Gilbert. These techniques correspond with the EPA-accepted professional judgement techniques (i.e., spatial analysis, temporal analysis).

DOE discussed the uncertainties and limitations of strictly following the approved flowchart with EPA and CDPHE on March 10, 1994 with the focus on reservoir sediment and surface water data incompatibilities in the approved process. In the ensuing work period, it became apparent that similar issues of technical inconsistency with the approved process emerged with the stream sediments, stream surface waters, and groundwater. These issues were discussed in the May 3, 1994 meeting with EPA, CDPHE, and DOE. DOE implemented the WOE evaluation approach as an alternative to the approved process for those media as well. The analyses steps performed in TM 4 are consistent with Region VIII Guidance (October, 1994) as well as national guidance (See Section 5.7, EPA, 1989). Clearly, DOE would prefer a higher level of statistical work in the analysis. However, as was pointed out in the document, in some instances, assumptions and other criteria in the process could not be met; therefore, the alternative within the envelope of guidance was taken (the WOE evaluation).

The WOE alternative was discussed with EPA and CDPHE, and their input sought in meetings on March 10, 1994 and again on May 3, 1994. In a EPA letter addressed to DOE, dated March 24, 1994 (RE: Operable Unit 3 Comparisons to Background Data), EPA states, "The available data characterizing background concentrations of reservoir sediments is sparse, therefore, a deviation from Dr. Gilbert's approach is warranted in the case of OU 3 reservoir sediments. In fact, we believe that if DOE were to use Dr. Gilbert's approach, the conclusions would be less supportable than the weight of evidence approach."

Comment 2a. On March 10, 1994, all parties agreed that the Gilbert methodology was not appropriate for reservoir sediments due to the physical differences between on site stream sediments and the off site reservoir sediments. There was no such agreement for the other environmental media within OU 3. We agreed that a weight of evidence approach could be used to address the question of whether or not metals and radionuclides are above background levels in the reservoir sediments. This approach was to be conducted as a first step in the COC selection in accordance with the accepted methodology. Instead, DOE conducted this analysis at the end of the process. The effect of manipulating the process is that chemicals which appear to contribute the largest proportion of the risk within the OU are later explained away as representing background conditions. The true anthropogenic risk drivers may not have been identified.

Response to Comment 2a: On May 3, 1994, DOE presented the COC selection approach used for TM 4 to EPA and CDPHE. It was agreed to by all parties at the meeting that the main OU 3 concern was plutonium and americium and that the level of effort associated with determining if metals are COCs could become disproportionate. Historically, and as early as August 1992, when OU 3 was used as the basis for a "Risk Assessment" seminar with the public, EPA, CDPHE, and DOE recognized that actinide contamination was the focal point of the study. At that time, and throughout the work plan development process, plutonium in soils was a main concern. The assessment of metals was regarded as lesser a concern. On this basis, a statistically based soils sampling program (which ultimately proved compatible with the approved COC process) was specified for the soils (IHSS 199). A sampling strategy to confirm that metals from the Rocky Flats Environmental Technology Site (RFETS) had not impacted the sediments and surface waters using some biased locations in the streams and reliance on existing reservoir sediment plutonium data was developed for metals and radionuclides in sediments, surface waters, and groundwater in the Work Plan (DOE, 1992). Confirmation that these media were not impacted would be inferred if detected concentrations appeared in accord with natural conditions. Thus, from the planning stage to present, it was

never envisioned that rigorous statistical methods would be applied on media other than the soils (IHSS 199). The Work Plan was developed in consultation with EPA, CDPHE as well as stakeholders from the Technical Review Group (TRG) and was approved by EPA and CDPHE in 1992. The following table summarizes the reasons why the compensatory WOE evaluations were necessary for the reservoir sediment, stream sediment, reservoir surface water, stream surface water, and groundwater data.

Table 1 Reasons for the Weight-of-Evidence Evaluation		
Medium	Reason(s)	Discussion
Reservoir sediment (All IHSSs)	No comparable background data set	The Background Geochemical Characterization Report (BGCR) does not contain sediment data from background reservoirs, lakes, or ponds. No other data sets from reservoirs along the front range were found with appreciable sample size. Although other OUs used background seep data from the BGCR, there is no evidence to support that the seep data is comparable to the OU 3 reservoir data.
Stream sediment: IHSS 200: 8 samples IHSS 201: 14 samples IHSS 202: 4 samples Stream surface water: IHSS 200: 4 total/1 dissolved IHSS 201: 4 total/2 dissolved IHSS 202: 0 Groundwater: IHSS 200: 1 well sampled 8 times, repeat samples. IHSS 201: 1 well sampled 8 times, repeat samples.	1. Too few OU 3 samples 2. Disproportionate sample sizes Background Data from the BGCR: Stream Sediments: 20-60 Stream Surface Water: 100 Groundwater: 49 wells (157 samples)	Preliminary statistical evaluations using the approved approach indicated that: 1. Satisfactory confidence and power in the inferential rigorous statistical tests was not possible because of the small sample sizes in the confirmation sampling approach. 2. Rigorous inferential statistical results could not be obtained with confidence owing to disproportionate sample sizes between the OU 3 and background data sets. 3. Incompatible groundwater comparisons
Reservoir surface water	No comparable background data set	The Background Geochemical Characterization Report does not contain surface water data from background reservoirs, lakes, or ponds. No other data sets from reservoirs along the front range were found with adequate sample size.

Relevant guidance (EPA, 1994; EPA, 1989; Gilbert, 1993) establish that in RFI/RI assessments chemical concentrations that are indistinguishable from background can be eliminated as COCs from the risk assessment (see Fig. 1 of Region VIII Guidance on COC identification (EPA, 1994). Therefore, focusing the OU 3 assessment on those compounds which can be distinguished from background is consistent to the guidance listed above.

The common sense WOE methodology, in fact, stems in part from Dr. Gilbert's original July 1993 report in which he discussed the use of professional judgment and Geochemical analysis as a significant part of his recommended approach (See Phase V discussion, Gilbert, 1993). In the same paper, Dr. Gilbert emphasized visual data presentations and their interpretations within the site specific setting. The Hi-Lo bar graphs and probability plots

(PROBPLOT), which are fundamental tools of the WOE evaluation method, are examples of visual data presentations (Comparing Hi-Lo bar graphs and drawing deductions about means, ranges and variations is analogous to comparing box and whisker plots for the same purpose). Probability plots were cited by Dr. Gilbert and were approved by EPA in the "Straw Man" approach (DOE, 1993a; EPA, 1993).

Originally, DOE proposed to perform the WOE evaluation as the first step of the identification process--as part of the Gilbert "Tool Box" (as presented in the strawman, EG&G, 1994a). Applying the WOE evaluation early in the process would have screened out many chemicals. Additionally, much of the WOE evaluation is part of the nature and extent of contamination evaluation. The COC selection approach (CPDHE/EPA/DOE, 1994) places a nature and extent of contamination evaluation following the COC selection steps. Therefore, in order to be consistent with this approach (CPDHE/EPA/DOE, 1994) (see Figure 1-1 in TM 4), the WOE evaluation was moved to the last step in the process. This approach adds more conservatism to the process by first applying the toxicity screen and allowing more attention to be focused on the potential risk drivers in the WOE evaluation.

Regardless of whether the WOE evaluation process is applied as the first step in the process or the last, the resulting COCs would be the same (see results of the CDPHE Conservative Screen for OU 3 where the WOE step was used first in selecting PCOCs). If applied first, arsenic and beryllium would be eliminated as PCOCs before the concentration-toxicity and PRG screens. If the WOE evaluation is applied last, these chemicals would be eliminated as PCOCs.

Comment 2b. A comparison of maximum chemical concentrations to corresponding preliminary remediation goals (PRGs) is meant to retain those chemicals which are present above the PRG, not to further exclude chemicals which have been identified as contributing the significant portion of the operable unit risk as a result of the concentration toxicity screen. DOE used the PRG comparison incorrectly in OU 3.

Response to Comment 2b: Those chemicals exhibiting maximum concentrations greater than the most conservative PRG (with respect to exposure route (oral or ingestion) and toxicity (carcinogenic or noncarcinogenic) were retained as PCOCs. The PRGs used are included in Attachment 1 to Appendix E. The PRGs are based on residential exposure parameters, with the exception of subsurface sediments which are based on office worker exposure parameters, and use a target risk of 1×10^{-6} or a hazard index equal to 1.0. Comparing the PRG screen results presented in Appendix D (Tables D-1 through D-9) and in Appendix E (Tables E-1 through E-9) with the final COCs in each medium (see Sections 4, 5, 6, and 7) illustrates that

no chemicals with concentrations exceeding a PRG were deleted from the COC selection process at this stage. Only beryllium in IHSS 201 surface sediments failed the concentration-toxicity screen and has a concentration greater than the PRG (1.6 mg/kg vs a PRG of 0.15 mg/kg). DOE's application of the PRG screen clearly achieves the intent of the EPA Region VIII COC Identification guidance (EPA, 1994).

All PCOCs were then subjected to the WOE evaluation for comparison to background levels. It is appropriate to apply the WOE to these PCOCs because some naturally occurring compounds such as arsenic exist in nature at concentrations greater than their respective PRGs.

Regardless of the order of when the PRG screen and background comparisons are performed, those chemicals which can be differentiated from the background per the WOE evaluation and those chemicals contributing a significant portion of the potential risks per the concentration-toxicity and PRG screens will be selected as COCs.

Comment 2c. The accepted statistical methodology for comparing remedial investigation data to background data, the "Gilbert Methodology", was not used for stream surface water, stream sediment, and groundwater. The reasons cited were "insufficient sample size and lack of a comparable data set." We believe the background Geochemical characterization data set is comparable and that it is possible that a statistical comparison can be conducted for these media although the power of the test may not be optimal.

Response to Comment 2c: There are at least four samples for most media by IHSS (see Table 1), and it is possible, mathematically, to perform the Gilbert statistical tests for comparison to background with so few samples and the lack of comparable data sets. However, the uncertainty introduced in the outcome of the statistical tests is likely greater than the approach used in the WOE evaluation. The WOE approach tries to use a variety of information rather than binary hypothesis tests (i.e., OU 3 concentrations greater than background or OU 3 concentrations less than background) that may or may not accurately reflect conditions at OU 3. Statistical analysis on data with so few data points would require additional confirmation. That confirmation was performed using the WOE evaluation.

The issue of whether the background and OU 3 stream surface water, stream sediment, and groundwater data are comparable is not wholly a statistical argument. This issue was discussed in the March 10, 1994 and May 3, 1994 meetings with EPA and CPDHE. An in-depth analysis and discussion of the physical aspects of where the OU 3 and background samples were collected is needed. If the data sets are not comparable from a physical sense

(i.e., environmental conditions and flow regimes), a statistically significant difference between site and background will be inconclusive because the test is evaluating the effect of more than one variable. The variable to be tested is the influence of Rocky Flats Plant operations. One will not be able to determine if a difference is the result of anthropogenic influences, due to Rocky Flats Plant operations, or the result of incomparable physical conditions.

The use of a point-by-point comparison of the OU 3 groundwater data to the upper tolerance limit (UTL) was approved by EPA and CDPHE in the February 14, 1994 meeting. If the point-by-point comparison is made, no arsenic and beryllium samples exceed the UTL and would, therefore, not qualify as COCs. Also, the groundwater data were not collected to characterize the aquifers within OU 3. Groundwater sample analyses results from the two monitoring wells located downgradient of Standley Lake and Great Western Reservoir exhibit differences in groundwater chemistry between the two well locations. Additionally, the results show differences from the wells contained in the Background Geochemical Characterization Report (BGCR). These differences are likely due to variations in water chemistry exhibited by different aquifers. Since the OU 3 monitoring wells are located in different hydrogeologic conditions than the BGCR wells, the data are not directly comparable. These results are illustrated on the Piper diagrams presented in TM 4 and were discussed in the May 3, 1994 meeting between EPA, CDPHE and DOE.

Comment 3, Section 3, Page 13. The COC selection process is to be applied by operable unit. DOE's application of the detection frequency criteria is by IHSS. This is incorrect. The entire OU data set should have been considered as a whole.

Response to Comment 3: According to the RFETS COC selection process guidance (CDPHE/EPA/DOE, 1994), COCs are selected using all data, for a particular medium, from an operable-unit. However, for OU 3, the selection of COCs on an OU-wide basis is not appropriate based on spatial, exposure, and different hydrologic and physical processes. Therefore, COCs were selected on an IHSS-basis.

The following points support selection of COCs on an IHSS-by-IHSS basis:

- Performing the concentration-toxicity screen on an IHSS-by-IHSS basis is the *most conservative approach* because it provides opportunity for more compounds to be retained as COCs in the detection-frequency screen. Non-detected data from one IHSS may contribute to lower the overall detection frequency below five percent and eliminate the chemical as a COC. Because of this artifact, a chemical detected greater than five percent of the time in one IHSS, may be eliminated as a COC.
- Performing the concentration-toxicity screen on an IHSS-by-IHSS basis is the *most conservative approach* because it provides opportunity for more compounds to be retained as COCs in the concentration-toxicity screen. For the entire OU data set, the maximum concentrations for arsenic and beryllium would represent the top 99 percent of the concentration-toxicity score excluding many other chemicals. However, in IHSSs that have smaller maximum concentrations, other chemicals may contribute to the top 99 percent of the concentration-toxicity score and pass the screen (i.e., be retained). As an example, the maximum arsenic sediment concentrations are as follows: 9.4 mg/kg in IHSS 200, 17.7 mg/kg in IHSS 201, and 10.4 mg/kg in IHSS 202. Using the arsenic concentration in IHSS 201 as the maximum OU 3 arsenic concentration, it would contribute almost 50 percent more to the concentration-toxicity score than if the 9.4 mg/kg and 10.4 mg/kg values were used on an individual IHSS basis.
- Each IHSS represents a distinct geographic location that is 1 to 2 miles from the other IHSSs. From a demographic and exposure perspective, different populations would likely frequent different reservoirs and it is not reasonable to aggregate the data in a manner that is inconsistent with exposure patterns. Consideration of population dynamics in the HHRA is discussed in EPA Guidance (EPA, 1989).
- Potential background, RFETS-related, and other anthropogenic sources of metals concentrations are different (e.g., Clear Creek Superfund site, mineral deposits, other commercial, industrial, or agricultural sources). These factors introduce much uncertainty when making comparisons to background by the Gilbert process or the WOE evaluation.

- The source of water for each IHSS are from different watersheds. Mower Reservoir receives approximately 100 percent of its water from the RFETS drainage basin, while Great Western Reservoir receives only 25 to 35 percent from the RFETS drainage basin and Standley Lake receives only 5 to 10 percent from the RFETS drainage basin.
- Exposure scenarios will differ between the IHSSs. For example, Great Western Reservoir may be drained, exposing the surface and potentially the subsurface sediments, while Standley Lake and Mower Reservoir will continue to be used for drinking water and irrigation purposes, respectively. Further, Standley Lake is widely used for recreation while Great Western Reservoir is not. Mower Reservoir is privately owned and used mainly for irrigation.
- The ability to effectively communicate risk to the public will be complicated by OU 3-wide COCs. For example, additional effort would be required to explain to the public that plutonium in Standley Lake is not a problem (i.e., no $^{239/240}\text{Pu}$ activities exceed the 1×10^{-6} PRG), when it has been identified as a COC. COCs identified in each IHSS accomplish the purpose of the COC selection process by focusing the assessment on those chemicals that will contribute significantly to potential risks. Communicating OU 3 risk to the public has been a central theme shared by EPA, CDPHE, and DOE from the outset of the project in 1990. EPA, CDPHE, and DOE could be criticized for taking too broad a view of OU 3.

Comment 4, Section 3, Page 14. Similar to the above comment c, the concentration toxicity screen was applied by IHSS whereas it should have been applied using the entire data set.

Response to Comment 4: This comment has been previously addressed in the Response to Comment 3.

Comment: The above deviations were considered serious enough to warrant an independent analysis of the OU 3 data and selection of COCs by the conventional methodology. The results of this can be summarized as follows:

SURFACE SOIL	Pu-239/240, Am-241
SEDIMENT	As, Be, Pu-239/240, Am-241
GROUNDWATER	As, Be, U-233/234

Response to Comment: The list of COCs developed by EPA is not based on EPA national guidance (EPA, 1989), EPA regional guidance (EPA, 1994), or the approved RFETS COC selection process (CDFHE/EPA/DOE, 1994; Gilbert, 1993; EG&G, 1994). The chemicals presented by EPA consider only detection frequency, essential nutrients, and toxicity and concentration. EPA's approach ignores the possibility that the reported compounds and their concentrations represent concentrations above background levels (i.e., contamination). This approach does not consider the statement in Section 5.7 of the Risk Assessment Guidance for Superfund (EPA, 1989), "In some cases, a comparison of sample concentrations with background concentrations (e.g., using geometric mean concentrations of the two data sets) is useful for identifying the non-site-related chemicals that are found at or near the site." and "If inorganic chemicals are present at the site at naturally occurring levels, they may be eliminated from the quantitative risk assessment."

In addition, EPA has not provided sufficient technical information on the methods used to select these COCs. The only information provided to DOE was attached to the informal EPA comments received from Bonnie Lavelle on December 6, 1994. The informal comments contain information that contradicts EPA's formal comments on TM 4. As an example, it appears that the handwritten corrections on Table 18 of the informal comments indicate additional steps beyond those described in the text. The table indicates the following steps were performed as part of the EPA COC selection process:

- essential nutrient screen
- frequency of detection screen
- concentration-toxicity screen

However, the handwritten corrections on Table 18 indicate a comparison to PRGs was performed to eliminate additional chemicals as COCs (e.g., barium in groundwater, surface water, and sediments). This action is similar to what was done in TM 4 and contradicts the deficiency noted in Comment 2b on the use of the PRG screen after the concentration-toxicity screen. Although the results of the background comparisons presented in TM 4 for surface soil were used to eliminate uranium-235 as a COC and a spatial analysis argument was used to eliminate uranium-233/234 and uranium-238 as COCs (indicated with handwritten corrections), neither of the screening steps were applied to the other media. Again, this is inconsistent with several of the comments provided by EPA and TM 4. In order to provide a technically verifiable basis for the COC list provided by EPA, DOE requests documentation of the methods and results of EPA's COC selection process.

The concentration-toxicity screen is a zero-sum-like approach, whereby, there will always be compounds retained, no matter how toxic, or at what concentration or whether they represent contamination from RFEIS. Significant likely ramifications of performing a HHRA using the above information include:

- Consideration of groundwater east of Standley Lake and Great Western Reservoir as impacted by Rocky Flats has no scientific basis in the regional hydrogeologic regime. Suggesting that contamination from Rocky Flats has migrated to these environs is not reasonable and could mislead decision makers and the public.
- Consideration of arsenic and beryllium as the contaminants of concerns, and, therefore, public health threats, also misleads decision makers and the public. Any discrepancy in their concentrations suggesting other than natural occurrence can be attributed to subtle variation in the physical and chemical environment and not to a release of contaminants in the environment.

Comment: Also, those chemicals without toxicity factors that are present above background and at greater than 5% frequency of detection should be identified for each medium. The potential impact on the human health risk must be addressed qualitatively in the human health risk assessment. The following chemicals are in this category:

SEDIMENT	aluminum, cesium, cobalt, lead, lithium, silicon, thallium
GROUNDWATER	aluminum, cobalt, iron, lead, lithium, silicon
SURFACE WATER	aluminum, cobalt, lead, lithium, silicon

Response to Comment: All of these compounds are naturally occurring and are ubiquitous. There is no rationale for their inclusion as COCs other than the fact that EPA has not published toxicity information for them. A qualitative discussion of this information regarding the above chemicals will be included in the HHRA.

SPECIFIC COMMENTS

Specific Comment 1, Section 2.2.2, Page 4. Differences in quality assurance (QA) procedures between the 1983-1984 data and more recently collected data are discussed in the second paragraph of this section. DOE conducted a statistical comparison to determine if the two data sets could be combined. DOE concluded that they were similar and could be combined. However, it is not clear whether the more recent samples were collected from the same sample locations as the 1983-1984 samples. If sampling locations were not the same, then the statistical tests are actually evaluating differences between locations or sampling methodology, as well as other potential differences. Additionally, because different QA procedures were used for 1983-1984 data, sample quantitation limits may not be comparable between the two data sets. For example, if the two data sets have different sample quantitation limits; they cannot be directly compared. These complications should be addressed in this section, and other sections which describe combining data.

Response to Specific Comment 1: The inclusion of the 1983-1984 sediment data was extensively discussed in the OU 3 Work Plan. The statistical basis for the sampling design and inclusion of the data follow the approved Work Plan. Many of the RFI/RI sediment samples were collected to correspond to known 1983 and 1984 sample locations (See Figures 2-2 and 2-3 in TM 4). Two pair-wise statistical tests were performed--only those locations with both sets of samples (RFI/RI samples and 1983 and 1984 samples) were included in the analysis. The paired location sample numbers are identified in memorandum by S. Blake/CH2M HILL, dated November 10, 1993 (included in Appendix A of TM 4 (DOE, 1994a). The paired analyses performed (a paired t-test and a Sign test) tests the hypothesis of whether the mean of the differences at each sample location are significantly different from zero. This type of analysis takes into account differences between sample locations and, therefore, differences between sampling locations is not an issue. Both statistical tests show no significant difference in the 1983/84 data and the Standley Lake data at a 95 percent confidence. However, the mean and median ^{239/240}Pu activity level of the 1983/84 Great Western Reservoir data is higher than the 1992 RFI/RI data. Based on these results, the 1983/84 data was combined with the RFI/RI data.

An assessment on the reported sample quantitation limits (SQLs) was not performed. Differences between the SQLs of the data sets may impact the results of the statistical comparison tests. Furthermore, as stated in the RFI/RI Work Plan for OU 3 (DOE, 1992), extensive QA/QC information is not readily available for the 1983/1984 sediment samples and,

after extensive investigation, the locations of several sample locations are not known. While these data do have QA/QC issues, one of the purposes of the OU 3 field program was to confirm historical data and use it to the maximum extent possible. Also, it was determined that the inclusion of the 1983/1984 sediment data for Great Western Reservoir would be conservative since these data have higher values than the RFI/RI data.

Specific Comment 2, Figure 3-4, Page 8 or 9 of Section 3. This figure presents the background comparison methodology. According to the Gilbert methodology, an additional step should be included in the flow chart before the slippage test. The slippage test should be used if the highest datum is a detect. If not, then the next step should be to determine if there are less than 20 percent nondetected samples in the site and background, and whether the site and background data are normally distributed. The figure should be corrected to include this step.

Response to Specific Comment 2: We agree with the comment. An additional step should have been identified in the flow chart, occurring before the slippage test, to check whether the largest background value is a detect. The slippage test is used only if the largest background data value is a detect. Although this step was inadvertently left off the flowchart, the background comparison methodology was employed correctly for the OU 3 surface soil data set. The flow chart should correspond to the approved flowchart in the Straw Man guidance (DOE, 1993a; EPA, 1993).

Specific Comment 3, Section 3.5, Page 14. This section describes the CTS screen used to select COCs and Appendix D presents the CTS tables. Although the description in Section 3.5 accurately explains how to conduct a CTS, the CTS tables do not present the information necessary to easily verify the results of the assessment. The tables in Appendix D should be revised to include the maximum detected concentration and toxicity value used for each chemical, as well as the chemical risk factor, total risk factor, and the ratio of each individual chemical risk factor to the total risk factor.

Response to Specific Comment 3: New concentration-toxicity information tables for the RFI/RI Report containing the additional information described in the comment will be provided on request to EPA.

Specific Comment 4, Section 3, Page 16. The weight of evidence evaluations fall short of EPA's expectations because no criteria were established or apparently applied to discriminate appropriate literature values from inappropriate ones. At a minimum, we expected some consideration of the geologic materials comprising the sediment background locations compared to OU 3 conditions, an evaluation of flow conditions, an evaluation of the uncertainty in each estimate of "background" from the literature (i.e., sample size, sampling methods, QA/QC considerations) and an evaluation of location of the "background" samples relative to anthropogenic sources of contamination. Instead of providing useful information, it introduces much uncertainty to the COC selection process. A comparison to other contaminated Superfund sites was also done with the OU 3 data. This has no relevance to the question of whether sediments, surface water, and groundwater in OU 3 contain chemicals above background concentrations.

Response to Specific Comment 4: All available information was gathered, beginning with information from the Background Geochemical Characterization Report (BGCR) (DOE, 1993b) and from areas along the Front Range. These data were supplemented by other Colorado and national data sets. A systematic process was used to evaluate benchmark data sets. The only data sets not included were some arsenic and beryllium background concentrations from the U.S. These concentrations were at similar levels as the arsenic and beryllium concentrations already presented. No other data sets found during research were eliminated.

The following sources, in order of preference, were accessed:

- Data from the BGCR
- Metro Denver data
- Front Range data
- Colorado data
- US data
- World data

Pertinent observations of these data sets include:

- Surface water data is from freshwater sources
- Majority of data presented in TM 4 are from US sources
- Some of the data is from the front range of the Rocky Mountains within 20 miles of OU 3
- Data published in scientific journals, books, or other scientific literature
- Data collected by agencies responsible for maintenance, operation, organization, etc. of a land use (contamination)
- The supporting information to perform a rigorous QA/QC evaluation was not available; however, most of the reviewed data were obtained from published scientific sources or organizations (e.g., USGS) and would not be expected to have been published without proper QA/QC.

Uncertainty does exist in the quality and usability of the benchmark data, but realizing this uncertainty when using these data in the comparisons, and combining the conclusion reached from these comparisons with the other WOE evaluation steps bolsters the conclusion that these data represent general background conditions as do the OU 3 data. These data sets have been published in scientific journals, books, or other scientific literature, and media which require a high level of QA/QC.

The WOE evaluation considers concentration levels for each chemical from each IHSS. Since each IHSS would likely receive contamination at different times from different release events, IHSS-specific contamination should be apparent in the evaluation. Based on the concentrations seen in these IHSSs, arsenic and beryllium concentrations are within the background ranges. Additionally, considering that 90 percent of the water going into Standley is from Clear Creek and only 25 to 35 percent of the water flowing into Great Western Reservoir is from the North and South Walnut Creeks, and approximately 100 percent of the water flowing into Mower Reservoir is from RFETS, the concentrations are remarkably similar; further supporting the determination that these metals are within the background ranges.

As an example of the similarity in concentrations, the arithmetic mean for arsenic concentrations in the stream sediments (creeks and drainages) of IHSSs 200, 201, and 202 are

5.3, 4.8, and 4.9 mg/kg, respectively, and in the reservoir surface sediments (lakes) are 4.9, 6.9, and 5.1 mg/kg, respectively. The arsenic concentration ranges are from 3.7 to 9.4, 2.2 to 7.8, and 3.0 to 6.8 mg/kg for stream sediments in IHSSs 200, 201, and 202, respectively; and 2.6 to 9.4, 1.2 to 17.7, and 2.2 to 10.4 mg/kg for reservoir surface sediments in IHSSs 200, 201, and 202, respectively. These comparisons suggest comparability, not divergence, in the low part per million range.

Comparing the stream sediment data reveals similar concentration levels. The BGCR arsenic range in stream sediments is 0.2 to 17.3 mg/kg with a mean of 2.4 mg/kg and the BGCR beryllium range is 0.15 to 1.3 mg/kg with a mean of 0.7 mg/kg. An arsenic concentration of 2.4 mg/kg translates to a 6×10^{-6} risk and a beryllium concentration of 0.7 mg/kg translates to a 5×10^{-6} risk (the risks are based on residential exposure parameters from the Programmatic Preliminary Remediation Goals document (DOE, 1994a). If arsenic and beryllium are considered COCs, then based on the analytical data all IHSSs--Great Western Reservoir, Standley Lake, and Mower Reservoir--and the entire area of each IHSS (i.e., every part of each stream and reservoir) are contaminated.

Following EPA's reasoning that the background data are not comparable to OU 3 conditions, based on a non-statistical comparison, the areas where the BGCR data were collected would then be considered contaminated, as would the Cherry Creek reservoir, the Rocky Mountain National Park lakes, the background stream sediments for the Lowry Landfill Superfund site, and the Great Lakes, Lake Adirondack, and Lake Michigan. Clearly, not all these areas have been contaminated to levels exceeding background. Rather, this illustration exemplifies the commonly observed natural variation in the physical environment. Subtle differences or variations do not normally indicate pollution as a source of variation. The concentration data used to represent the benchmark (background) levels is very consistent (see the bar graphs in TM 4, for example, Figure 5-1). There are no apparent large fluctuations and only the data identified as site contamination from Superfund sites are much greater than all other concentrations. Comparison to concentration levels from Superfund sites illustrates the typically encountered chemical concentration levels found at hazardous waste sites. Based on experience, the levels of contamination from the release of hazardous substances is not subtle and the identity of released contaminants is normally indicated by appreciable increases above natural and wide-spread anthropogenic levels.

Additionally, the Gilbert process (Gilbert, 1993; DOE, 1994b; DOE, 1993; EG&G, 1994; EPA, 1993) includes three professional judgment guidelines that are used in conjunction with the statistical tests and do not require the use of benchmark data:

- Spatial distribution arguments
- Temporal distribution arguments
- Pattern recognition concepts

Spatial distribution argument and temporal distribution arguments are an integral part of the WOE evaluation and agree with the results of a comparison to benchmark data.

Specific Comment 5, Section 3.10, Page 29. This section describes how Phase 1 Historical Public Exposure Studies were used to confirm chemicals as COCs. The purpose of the historical studies was not to support risk assessment or COC selection for OU 3. As stated in this section, more than 8,000 chemicals were identified as having been used at the Rocky Flats site, but "the list was reduced to those chemicals that were most likely to have posed an offsite human health hazard under routine historical plant operations." The focus of historical investigation was not to select COCs. For example, Table 3-3 lists the materials of concern by the RFETS health studies. Most of these chemicals were eliminated as COCs through the selection process used in TM 4.

Response to Specific Comment 5: The materials of concern presented in the Phase I Historical Public Exposure Studies support the results of the WOE evaluation and were presented in TM 4 for information purposes only. Although, the purpose of the Phase I studies was not to support OU 3 activities, the methods used to identify the materials of concern are generally more rigorous for identifying potential sources of contamination to the offsite area than source definition methods related to the OU 3 RFI/RI activities. According to ChemRisk, speaking to the Phase I Health Studies:

"The initial tasks (including the inventory and selection of COCs) deal with the review and compilation of historical information for the purposes of selecting specific radionuclides and chemicals that warrant detailed study as well as accidents or incidents that may have affected the offsite public." -- ES&T Vol. 26, No. 7

In the study ChemRisk employed a WOE method which does consider the toxicological properties of the materials used at Rocky Flats and also considers accidents or other incidents beyond routine plant operations. Only the chemicals classified as materials of concern that were used in sufficient quantities or were released during any routine or non-routine event to be considered a contaminant source. For example, according to the study, arsenic was not used

during plant operations and there were no known releases of arsenic. Additionally, beryllium, a material of concern, is a potential source. But upon further analysis of the concentration data within OU 3, something not performed as part of the Phase I Health Studies, beryllium is not a COC.

Based on the above information, it is reasonable and scientifically appropriate to use the results of these methods to support risk assessments and COC selection tasks related to Rocky Flats.

Specific Comment 6, Section 4, Page 4. Table 4-2 is inconsistent with the information in Appendix B. Appendix B indicates that plutonium activity in soils is not normally distributed. Therefore, the t-test is not a valid statistical test.

Response to Specific Comment 6: We disagree with the EPA comment that Table 4-2 is inconsistent with Table B-1 in Appendix B regarding the t-test. The criteria for performing the t-test is defined as follows:

“IF A) EITHER both background and OU data contain at least 20 data points, OR both distributions are normally distributed
AND B) less than 20% of the background and OU data are classified as non-detects,
THEN use the t-test.”

None of the data analyzed follow a normal (or log normal) distribution in both the OU 3 and background. However, Table B-1 shows $^{239/240}\text{Pu}$ contains at least 20 data points in both OU 3 and background (OU 3 -109, background-20). Therefore, according to the criteria above, a t-test should be performed and the resulting p-value is shown in Table 4-2.

Specific Comment 7, Appendix G. This appendix provides probability plots used in the weight-of-evidence evaluation. Radium-226 is not discussed in the text although a probability plot has been provided for it. Radium-226 should be discussed in this appendix.

Response to Specific Comment 7: The probability plot was inadvertently included in Appendix G. Radium-226 is not an element for analysis under the OU 3 Work Plan. A few samples were inadvertently and inconsistently analyzed for Radium-226. No Radium-226 concentrations exceeded the residential PRGs. Assessment of Radium-226 will be deleted from the OU 3 Project.

REFERENCES

- DOE, 1994a. United States Department of Energy, Technical Memorandum No. 4, Human Health Risk Assessment for Operable Unit 3, Rocky Flats Environmental Technology Site, Chemicals of Concern Identification. Environmental Restoration Program, Golden, Colorado, September 23, 1994.
- DOE, 1994b. United States Department of Energy, Rocky Flats Plant Site-Wide Quality Assurance Project Plan for CERCLA Remedial Investigation/Feasibility Studies and RCRA Facility Investigations/Corrective Measures Studies Activities. January 5, 1994.
- DOE, 1993a. United States Department of Energy, Strawman of the statistical background comparison methods.
- DOE, 1993b. United States Department of Energy, Background Geochemical Characterization Report, September 30, 1993.
- DOE, 1992. United States Department of Energy, RFI/RI Work Plan for Operable Unit 3 Rocky Flats Plant. Environmental Restoration Program. (Manual 21100-WP-OU3.1, 02/28/92). Golden, Colorado, February 28, 1992.
- EPA, 1989. United States Environmental Protection Agency, Risk Assessment Guidance for Superfund, Volume 1: Part A, Office of Emergency and Remedial Response. EPA/540/6-90/008. October 1990.
- IAG, 1991. Rocky Flats Interagency Agreement Between the State of Colorado, the Environmental Protection Agency, and the Department of Energy, January 1991.
- CDPHE/EPA/DOE, 1994. Colorado Department of Health and Environment, United States Environmental Protection Agency, and the United States Department of Energy. Presentation on the Conservative Screen Process for Identification of Source Areas and Data Aggregation for Calculation of Exposure Point Concentrations. June 3, 1994.

CDPHE/EPA, 1993. Colorado Department of Health and Environment, United States Environmental Protection Agency, Background Comparisons approval letter from CDPHE and EPA. Resumption of Baseline Risk Assessment Work. Letter from Joan Sowinski (CDPHE) and Robert L. Duprey (EPA) to James K. Hartman (DOE). November 18, 1993.

DOE, 1992. United States Department of Energy, Guidance for Conducting Statistical Comparisons of RFI/RI Data and Background Data at the Rocky Flats Plant. Document No. 93-RF-14529, 11/30/93. November 30, 1993.

EG&G, 1994. EG&G Rocky Flats, Inc., Methodology for Statistical Comparison of Data to Background. EG&G Memorandum 94-RF-02971-SG-179-94, Golden, Colorado. March 14, 1994.

EPA, 1995. United States Environmental Protection Agency, Review comments on Technical Memorandum No. 4, January 4, 1995.

EPA, 1994. United States Environmental Protection Agency, Region VIII, Evaluating and Identifying Contaminants of Concern for Human Health. Document No. RA-03. September 1994.

EPA, 1993. United States Environmental Protection Agency, EPA comments on the Strawman of the statistical background comparison methods.

Gilbert, 1993. Richard O. Gilbert, Recommended Process for Implementation by Rocky Flats Plant (RFP) to Compare Environmental Restoration Site Analytical Results Obtained in Operable Units (OU) to Background Concentrations. July 30, 1993.

Enclosure 3

**EPA's Informal Review Comments on the COCs Identification TM 4
with COC Selection Enclosure
(Received December 6, 1994)**

100-8-34 VOL 10140

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EPA noted the following deviations from the standard process for selecting contaminants of concern:

a. Section 2, Page 27: All data collected under the operable unit 3 (OU 3) field sampling program should be considered when selecting contaminants of concern (COCs). Potential exposure pathways should not be used to limit the data sets under consideration. Subsurface sediments in Standley Lake and Mower Reservoir were excluded incorrectly in DOE's analysis.

b. Section 3, Page 1: The COC selection process as described on this page and illustrated in Figure 3-1 deviates from the process accepted by EPA, CDPHE, and DOE in three ways:

1. On March 10, 1994, all parties agreed that the Gilbert methodology was not appropriate for reservoir sediments due to the physical differences between on site stream sediments and the off site reservoir sediments. There was no such agreement for the other environmental media within OU 3. We agreed that a weight of evidence approach could be used to address the question of whether or not metals and radionuclides are above background levels in the reservoirs. This approach was to be conducted as the first step in the COC selection in accordance with the accepted methodology. Instead, DOE conducted this analysis at the end of the process. The effect of manipulating the process is that chemicals which appear to contribute the largest proportion of the risk within the OU are later explained away as representing background conditions. The true anthropogenic risk drivers may not have been identified.

2. A comparison of maximum chemical concentrations to corresponding preliminary remediation goals (PRGs) is meant to retain those chemicals which are present above the PRG, not to further exclude chemicals which have been identified as contributing the significant portion of the operable unit risk as a result of the concentration toxicity screen. DOE used the PRG comparison incorrectly in OU 3.

3. The accepted statistical methodology for comparing remedial investigation data to background data, the "Gilbert Methodology", was not used for stream surface water, stream sediment, and groundwater. The reasons cited were "insufficient sample size and lack of a comparable data set". We believe the background geochemical characterization data set is comparable and that it is possible that a statistical comparison can be conducted for these media although the power of the test may not be optimal.

c. Section 3, Page 13: The COC selection process is to be applied by operable unit. DOE's application of the detection frequency criteria is by IHSS. This is incorrect. the entire OU data set should have been considered as a whole.

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d. Section 3, Page 14: Similar to the above comment c, the concentration toxicity screen was applied by IHSS whereas it should have been applied using the entire data set.

EPA felt that the above deviations were serious enough to warrant an independent analysis of the OU 3 data and selection of COCs by the conventional methodology. The results of this independent analysis are enclosed and can be summarized as follows:

SURFACE SOIL Pu-239/240, Am-241

SEDIMENT As, Be, Pu-239/240

GROUNDWATER Sb, As, Be

Also, those chemicals without toxicity factors that are present above background and at greater than 5% frequency of detection should be identified for each medium. The potential impact on the human health risk must be addressed qualitatively in the human health risk assessment. EPA has identified the following chemicals in this category:

SEDIMENT aluminum, cobalt, lead, lithium, silicon

GROUNDWATER aluminum, cobalt, iron, lead, lithium, silicon

SURFACE WATER aluminum, cobalt, lead, lithium, silicon

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SPECIFIC COMMENTS:

1. Section 2.2.2, Page 4. Differences in quality assurance (QA) procedures between the 1983-1984 data and more recently collected data are discussed in the second paragraph of this section. DOE conducted a statistical comparison to determine if the two datasets could be combined. DOE concluded that they were similar and could be combined. However, it is not clear whether the more recent samples were collected from the same sample locations as the 1983-1984 samples. If sampling locations were not the same, then the statistical tests are actually evaluating differences between locations or sampling methodology, as well as other potential differences. Additionally, because different QA procedures were used for 1983-1984 data, sample quantitation limits may not be comparable between the two data sets. For example, if the two data sets have different sample quantitation limits, they cannot be directly compared. These complications should be addressed in this section, and other sections which describe combining data.

★ 2. Figure 3-4, Page 8 or 9 of Section 3. This figure presents the background comparison methodology. According to the Gilbert methodology, an additional step should be included in the flow chart before the slippage test. The slippage test should be used if the highest datum is a detect. If not, then the next step should be to determine if there are less than 20 percent nondetected samples in the site and background, and whether the site and background data are normally distributed. The figure should be corrected to include this step.

★ 3. Section 3.5, Page 14. This section describes the CTS screen used to select COCs and Appendix D presents the CTS tables. Although the description in Section 3.5 accurately explains how to conduct a CTS, the CTS tables do not present the information necessary to easily verify the results of the assessment. The tables in Appendix D should be revised to include the maximum detected concentration and toxicity value used for each chemical, as well as the chemical risk factor, total risk factor, and the ratio of each individual chemical risk factor to the total risk factor.

★ 4. Section 3, Page 16. The weight of evidence evaluations fall short of EPA's expectations because no criteria were established or apparently applied to discriminate appropriate literature values from inappropriate ones. At a minimum, we expected some consideration of the geologic materials comprising the sediment background locations compared to OU 3 conditions, an evaluation of flow conditions, an evaluation of the uncertainty in each estimate of "background" from the literature (i.e., sample size, sampling methods, QA/QC considerations) and an evaluation of location of the "background" samples relative to anthropogenic sources of contamination. Instead of providing useful information, it introduces much uncertainty to the COC selection process. A comparison to other contaminated Superfund sites was also done with the OU 3 data. This has no relevance to the question of whether sediments, surface water, and groundwater in OU 3 contain chemicals above background concentrations. EPA will accept only the probability plot analysis and the temporal analysis in a weight of evidence evaluation.

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5. Section 3.10, Page 29. This section describes how Phase I Historical Public Exposure Studies were used to confirm chemicals as COCs. The purpose of the historical studies was not to support risk assessment or COC selection for OU3. As stated in this section, more than 8,000 chemicals were identified as having been used at the Rocky Flats site, but "the list was reduced to those chemicals that were most likely to have posed an offsite human health hazard under routine historical plant operations." The focus of historical investigation was not to select COCs. For example, Table 3-3 lists the materials of concern by the RFETS health studies. Most of these chemicals were eliminated as COCs through the selection process used in TM4.
6. Section 4, Page 4. Table 4-2 is inconsistent with the information in Appendix B. Appendix B indicates that plutonium activity in soils is not normally distributed. Therefore, the t-test is not a valid statistical test.
- * 7. Appendix G. This appendix provides probability plots used in the weight-of-evidence evaluation. The probability plots are acceptable and well-presented. However, radium-226 is not discussed in the text although a probability plot has been provided for it. Radium-226 should be discussed in this appendix.

1.0 INTRODUCTION

PRC Environmental Management, Inc. (PRC) evaluated sampling data for operable unit 3 (OU3) at Rocky Flats Environmental Technology Site (RFETS). Summary statistics for surface water, groundwater, surface soil, and sediment were provided to EPA by PRC on October 21, 1994. In this report, chemicals of concern (COCs) are selected for each environmental medium using essential nutrient information, frequency of detection criteria, and a concentration-toxicity screen (CTS). A background comparison was not conducted. Section 2.0 describes the results of the frequency of detection and essential nutrient evaluation. Section 3.0 describes the results of the CTS for each medium. A CTS screen is not necessary for all sites, according to the Rocky Flats Plant Final Human Health Risk Assessment Template (EPA 1994). Instead, it should be used to reduce the list of COCs only when numerous chemicals have been detected at a site. The CTS was used for all media in this report; however, it probably was not necessary for radionuclides in any medium. Section 4.0 contains the references.

2.0 FREQUENCY OF DETECTION AND ESSENTIAL NUTRIENT EVALUATION

Tables 1 through 4 (previously submitted to EPA) presented the summary statistics for each medium. These tables were used to evaluate frequency of detection for each chemical in each medium. Any chemical with a frequency of detection of 5 percent or less was eliminated as a COC. All chemicals detected in OU3 soil and groundwater were detected with a frequency greater than 5 percent. In surface water, cyanide and beryllium were detected at frequencies of 4 and 2 percent, respectively. They were not retained as COCs for surface water. Thallium in sediments was also eliminated as a COC based on the frequency of detection; it was detected at a frequency of 2 percent.

Tables 5 through 7 of this report show the essential nutrient comparison. Either maximum concentrations or 95 percent upper confidence limits (95 UCLs) of the arithmetic mean were used to calculate intakes. For surface water and groundwater, an intake of 2 liters per day was assumed. For sediments, 100 milligrams per day was used. Only radionuclides were reported for soils; therefore, this comparison was not conducted for soils. The recommended daily allowance (RDA) or safe and adequate daily intake value for each nutrient (NAS 1989) was used for comparison to the calculated intake to determine if site concentrations were below an unacceptable level.

Table 5 presents the results of the comparison for groundwater. Maximum concentrations were used for calcium, iron, magnesium, and potassium because the calculated 95 UCLs exceeded the maximum values of the data. The 95 UCLs were used for copper, manganese, and zinc. Only iron exceeded the recommended daily allowance; however, no reference dose (RfD) is available for iron. Therefore, it was retained as a COC, but was not evaluated in the CTS for groundwater.

The essential nutrient comparison for surface water is presented in Table 6. The 95 UCL concentrations were used for all chemicals. Estimated intakes of calcium, copper, iron, magnesium, manganese, potassium, sodium, and zinc were all below their respective RDAs and SADDIs. All were eliminated as COCs.

Table 7 presents the essential nutrient comparison for sediments. The 95 UCL concentrations were used for all chemicals. Estimated intakes of calcium, copper, iron, magnesium, manganese, potassium, sodium, and zinc were all below the RDAs and SADDIs and were eliminated as COCs.

3.0 CTS EVALUATION

Table 8 through 17 present the CTS for each medium. Noncarcinogenic and carcinogenic chemicals were separately evaluated for each medium. Radionuclides were also evaluated separately for each medium. The CTS was conducted using maximum detected values and EPA's most conservative toxicity value for each chemical. That is, the lowest RfD for noncarcinogens and the highest carcinogenic slope factor (CSF) for carcinogens were used. For radionuclides, the higher of the ingestion and inhalation slope factor was used. External exposure slope factors were not used for the CTS screen because they are in different units than other radionuclide slope factors. All toxicity units must be the same to conduct a CTS.

The maximum detected concentration for each chemical were divided by the RfD or multiplied by the CSF to produce a chemical-specific risk factor. The risk factors were summed to produce a total risk factor. Chemical-specific risk factors were then divided by the total risk factor, resulting in a ratio that represents the contribution of risk for each chemical. A ratio of 0.01 or greater in a CTS indicates that the chemical contributes 1 percent or more of the total site-related risk. Chemicals with a ratio of 0.01 or greater were retained as COCs. Only chemicals with a toxicity value can be included in a CTS. All chemicals without toxicity values were retained as COCs. For this report, it was assumed that the reported chromium was all hexavalent. A speciation analysis to determine levels of trivalent and hexavalent chrome was not available.

Tritium was also detected in sediments but was not included in the CTS. It was reported in units of picocuries per liter (pCi/L) and, therefore, could not be evaluated with other radionuclides, which were reported in units of picocuries per gram (pCi/g). Tritium in sediments was retained as a COC.

COCs for each medium are summarized in Table 18 and reasons for excluding chemicals as COCs have also been listed.

4.0 REFERENCES

National Academy of Science (NAS). 1989. National Research Council.

U.S. Environmental Protection Agency (EPA). 1994. Rocky Flats Plant, Final Human Health Risk Assessment Template. August.

TABLE 9
ROCKY FLATS RISK ASSESSMENT TEMPLATE
COC SELECTION, CONCENTRATION-TOXICITY SCREEN
NONCARCINOGENS, GROUNDWATER

Analyte	Maximum Concentration ($\mu\text{g/L}$)	Toxicity Value (mg/kg-day)	Chemical- Specific Risk Factor (R_i)	Ratio of R_i/R_j
Barium	165	0.07	2,357	1.2E-01
Molybdenum	9.8	0.005	1,960	1.0E-01
Selenium	1.6	0.005	320	2.0E-02
Strontium	3,860	0.6	6,433	3.3E-01
Vanadium	59.9	0.007	8,557	4.4E-01
Total Risk Factor (R_j)			19,627	

Notes:

$\mu\text{g/L}$ Micrograms per liter
 mg/kg day Milligrams per kilograms - day

TABLE 11
ROCKY FLATS RISK ASSESSMENT TEMPLATE
COC SELECTION, CONCENTRATION-TOXICITY SCREEN
RADIONUCLIDES, GROUNDWATER

Analyte	Maximum Concentration (pCi/L)	Toxicity Value (risk/pCi)	Chemical-Specific Risk Factor (Rf)	Ratio of Rf/Rf
Americium-241	0.0044	3.2E-08	1.4E-10	8.0E-04
Plutonium-239/240	0.0034	3.8E-08	1.3E-10	7.0E-04
Uranium-233/234	4.84	2.7E-08	1.3E-07	7.0E-01
Uranium-235	0.2899	2.5E-08	7.2E-09	4.0E-02
Uranium-238	2	2.4E-08	4.8E-08	2.6E-01
Total Risk Factor (Rf)			1.9E-07	

Notes:

pCi/g PicoCuries per gram
risk/pCi Risk per picoCurie

TABLE 13
 ROCKY FLATS RISK ASSESSMENT TEMPLATE
 COC SELECTION, CONCENTRATION-TOXICITY SCREEN
 CARCINOGENS, SURFACE WATER

Analyte	Maximum Concentration ($\mu\text{g/L}$)	Toxicity Value (mg/kg-day)	Chemical- Specific Risk Factor (R_i)	Ratio of R_i/R_j
Arsenic	6.6	50	330	1.1E-01
Cadmium	9	6.3	56.7	2.0E-01
Chromium	65.8	41	2,697.8	8.7E-01
Nickel	33	0.84	27.7	1.0E-02
Total Risk Factor (R_j)			3,112.2	

Notes:

$\mu\text{g/L}$ Micrograms per liter
 mg/kg-day Milligrams per kilograms - day

TABLE 14
ROCKY FLATS RISK ASSESSMENT TEMPLATE
COC SELECTION, CONCENTRATION-TOXICITY SCREEN
RADIONUCLIDES, SURFACE WATER

Analyte	Maximum Concentration (pCi/L)	Toxicity Value (risk/pCi)	Chemical- Specific Risk Factor (R _i)	Ratio of R _i /R _j
Americium-241	0.018	3.2E-08	5.8E-10	7.1E-03
Plutonium-239/240	0.03	3.8E-08	1.1E-09	1.4E-02
Tritium	144.3	7.8E-14	1.1E-11	1.4E-04
Uranium-233/234	1.3	2.7E-08	3.5E-08	4.3E-01
Uranium-235	0.71	2.5E-08	1.8E-08	2.2E-01
Uranium-238	1.1	2.4E-08	2.6E-08	3.3E-01
Total Risk Factor (R _j)			8.1E-08	

Notes:

pCi/g PicoCuries per gram
risk/pCi Risk per picoCurie

TABLE 15
ROCKY FLATS RISK ASSESSMENT TEMPLATE
COC SELECTION, CONCENTRATION-TOXICITY SCREEN
NONCARCINOGENS, SEDIMENT

Analyte	Maximum Concentration (mg/kg)	Toxicity Value (mg/kg-day)	Chemical- Specific Risk Factor (Ri)	Ratio of Ri/Rj
Acetone	0.047	0.1	0.47	6.2E-06
Antimony	17.3	0.0004	43,250	5.7E-01
Barium	329	0.07	4,700	6.0E-02
2-Butanone	0.014	0.29	0.05	6.3E-07
Mercury	0.6	0.0003	2,000	3.0E-02
Molybdenum	23.7	0.005	4,740	6.0E-02
Selenium	6.7	0.005	1,340	2.0E-02
Silver	16.5	0.005	3,300	4.0E-02
Strontium	423	0.6	705	1.0E-02
Tin	51.4	0.6	85.7	1.1E-03
Toluene	0.016	0.2	80.0	1.0E-06
Vanadium	114	0.007	16,286	2.1E-01
Xylene	0.002	2	0.001	1.3E-08
Total Risk Factor (Rj)			76,487	

Notes:

ng/kg Milligrams per kilogram
mg/kg-day Milligrams per kilograms - day

TABLE 16
ROCKY FLATS RISK ASSESSMENT TEMPLATE
COC SELECTION, CONCENTRATION-TOXICITY SCREEN
CARCINOGENS, SEDIMENT

Analyte	Maximum Concentration (mg/kg)	Toxicity Value (mg/kg-day)	Chemical-Specific Risk Factor (Ri)	Ratio of Ri/Rj
Arsenic	36.2	50	1,810.0	.55E-01
Beryllium	2.3	8.4	19.3	1.0E-02
Cadmium	7.0	6.3	44.1	1.0E-02
Chromium	33.7	41	1,381.7	4.2E-01
Methylene Chloride	0.005	0.0075	0.04	4.0E-05
Nickel	72.7	0.84	61.1	2.0E-02
Total Risk Factor (Rj)			3,316.2	

Notes:

mg/kg Milligrams per kilogram
mg/kg-day Milligrams per kilograms - day

TABLE 17
ROCKY FLATS RISK ASSESSMENT TEMPLATE
COC SELECTION, CONCENTRATION-TOXICITY SCREEN
RADIONUCLIDES, SEDIMENT

Analyte	Maximum Concentration (pCi/g)	Toxicity Value (risk/pCi)	Chemical- Specific Risk Factor (R _i)	Ratio of R _i /R _j
Americium-241	1.02	3.2E-08	3.3E-08	7.0E-02
Cesium-137	0.57	2.8E-11	1.6E-11	3.4E-05
Plutonium-239/240	4.03	3.8E-08	1.5E-07	3.3E-01
Polonium-210	3.81	2.6E-09	9.9E-09	2.1E-02
Radium-226	2.2	3.0E-09	6.6E-09	1.0E-02
Radium-228	2.2	6.9E-10	1.5E-09	3.0E-03
Strontium-89/90	2.2	6.2E-11	1.4E-10	2.9E-04
Uranium-233/234	5.4	2.7E-08	1.5E-07	3.1E-01
Uranium-235	0.56	2.5E-08	1.4E-08	3.0E-02
Uranium-238	4.4	2.4E-08	1.1E-07	2.2E-01
Total Risk Factor (R _j)			4.7E-07	

Notes:

pCi/g PicoCuries per gram
risk/pCi Risk per picoCurie

TABLE 18
ROCKY FLATS PLANT RISK ASSESSMENT TEMPLATE
COC SELECTION, COC SUMMARY TABLE

Medium	Essential Nutrients	Frequency of Detection (<5%)	Eliminated by CTS	COCs	Reason Code
Sediment	Calcium Copper Iron Magnesium Manganese Potassium Sodium Zinc	Thallium	Acetone 2-Butanone Methylene chloride Tin Toluene Xylene Cs-137 Ra-228 Sr-89/90	Aluminum	③
				Antimony	④ (W-5)
				Arsenic	④
				Barium	③
				Beryllium	③
				Cadmium	③
				Caesium	③ RADIATION
				Chromium	③
				Cobalt	④ (W-6)
				Lead	③
				Lithium	③
				Mercury	③
				Molybdenum	④
				Nickel	③
				Selenium	③
				Silver	③
				Silicon	③
				Strontium	③
				Vanadium	③
				Am-241	③
				Pu-239/240	④ (W-5!6)
				Po-210	③
				Ra-226	③
				U-233/234	③
				U-235	③
				U-238	③
				Tritium	③

Enclosure 4

**Rocky Flats Environmental Technology Site
Human Health Risk Assessment Meeting Minutes**

- 1. February 14, 1994**
- 2. March 10, 1994**
- 3. May 3, 1994**

EPA Letter dated March 24, 1994, Recommending Weight of Evidence Approach



MEETING NOTES

PROJECT NUMBER _____

NOTES ISSUED BY _____

DATE _____

SHEET _____

BY _____

SUBJECT: RFP OU 3

MEETING

DATE: 5/3/94 LOCATION CHM HILL

ATTENDEES:

SEE ATTACHED LISTNOTES BY: KAREN WIEMELT / CHM HILL

REGION _____

TOPICS DISCUSSED

ACTION/NOTES

OVERVIEW

Bonnie Darrall/EPA: For WP, we knew ground-water wasn't a pathway. The wells were put in to address any public concern.

Bob Pink/DOE: Another purpose was to confirm that Pu in Reservoir sediments wasn't migrating.

Michael Guillaume/ACVIRRE: Our approach to the SW and sediment sampling was to achieve a # of samples that met a certain power - that # of samples is different from what # is req'd for the Gilbert process. The Gilbert approach wasn't designed at the WP stage.

EPA & CHM will talk with their internal resources about the approach for metals. They will provide input by next Tuesday.



MEETING NOTES

PROJECT NUMBER

SHEET 1 OF 3

NOTES ISSUED BY

REGION

DATE

SUBJECT: RFP OU 3 BACKGROUND EVALUATION

MEETING

DATE: 3/10/94

LOCATION EPA REG VIII

ATTENDEES:

BONNIE LAVELLE/EPA

PICK ROBERTS/EG&G

KAREN WIEMELT/CH2M

DAVE NORRIS/COH

MIKE BEDAN/CH2M HILL

HILL

MICHAEL GUILLAUME/AQUIFERE

JULIE REYNOLDS/CH2M HILL

MARK BUDAY/EG&G

DENNIS SMITH/CH2M HILL

NOTES BY:

REGION

TOPICS DISCUSSED

ACTION/NOTES

ROCK CREEK

EPA & COH think Rock Creek data set can be used for metals and Uranium. The area is in question for Pu and Am. Michael Guillaume explained that Whiting's area of influence extends so far to the north because there are so few data points to the north.

ACTION: Use the Rock Creek data set for the background comparison for surface soils. EPA and COH agree that this data set is fine for metals and Uranium but there is some uncertainty about the data set for Pu and Am. Since preliminary evaluations using the GTH approach show Pu and Am are COCs using Rock Creek data set, it is acceptable to use Rock Creek. Include a discussion of the uncertainty associated w/ the Rock Creek data set in the COC TM.

RESERVOIR SEDIMENTS

The stream and trap data sets are not physically the same as the reservoir bottom. The difference is that other data are very limited (typically one data pt & no AALC).

We can't use std Gilbert approach. we need an alternate approach

ACTION: look at upstream conditions. lie

Werner & Winkert, go through Gilbert

approach on 013 stream sed & background geochron. Dr. Robert stream sed, identify

also be seen in reservoirs keeping the following items in mind:

1. stream sed have been scoured, reservoir sed could have more cocs
2. GWE and standard hole have many other influences

We will derive from the "approved process" for Reservoir sediments. Professor

judgement will need to be used.

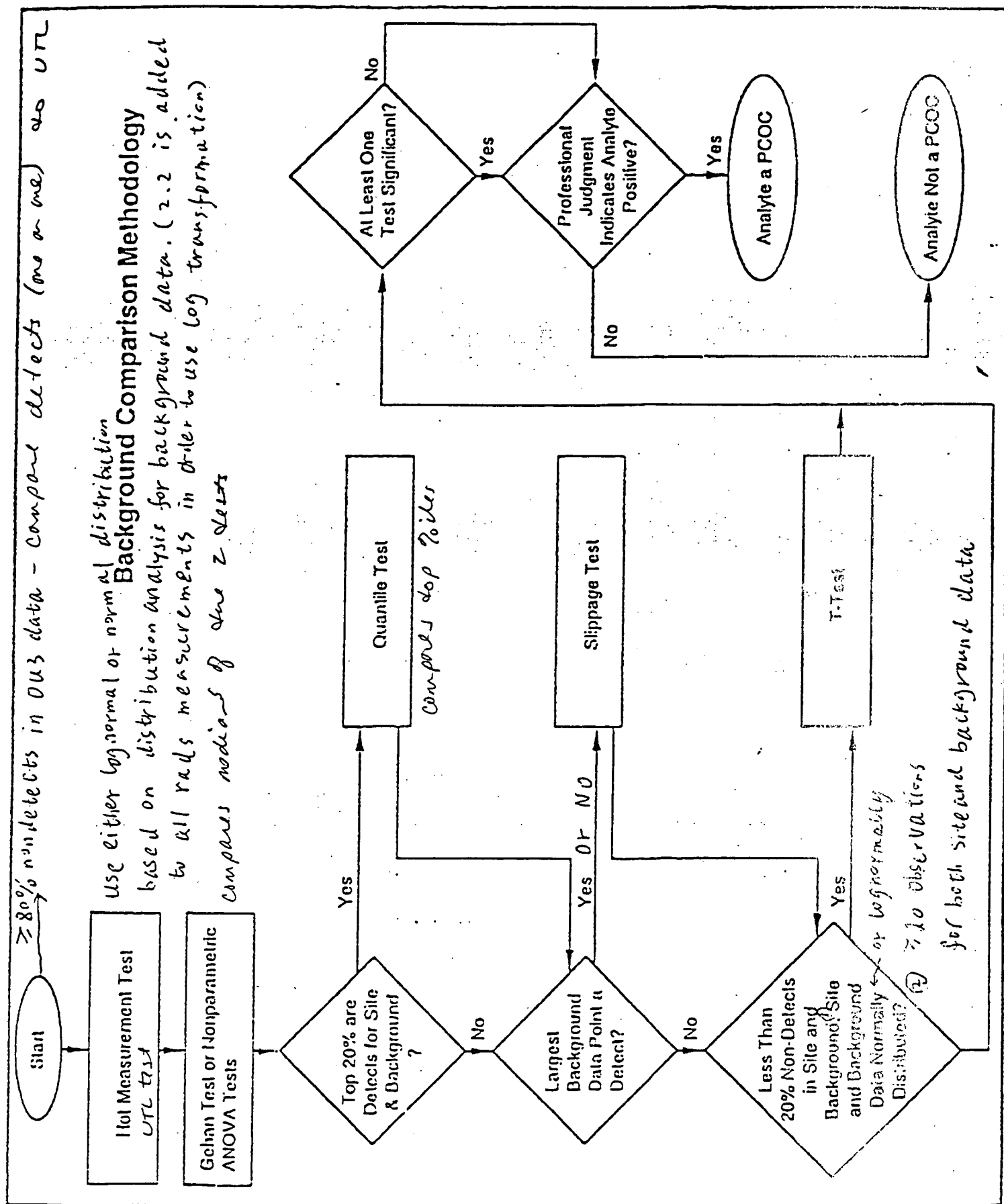
EPA and CCH will draft a letter documenting their buy-in to the deviation from the Gilbert approach. Weight of evidence from other sources and professional judgement will be factored in.

[Signature]
Dave Norbury
EPA
CCH

EC6

For JEL Page

101



OU 3 3/24

data can be used to
compare to 970-6

- 4 ~~2001~~ 2001, 21 days
② silver. body, & yellow tail

- solubility
- ng content

March 10, 1994

7

OU 3 Background Evaluation

I Proposed Process BGCR stream sed.

- o Statistical
- o Literature
- o Benchmarking

OU 3 stream sed

↓
COCs = PCOCs in reservoir
limitation: scouring
not considered

use reservoir (CC & Chat.)

15th, 16th - HAP work
studies.

Use OUs 4 & 5 also

II Surface Soils

III Sediments

IV Other

Bonnie: Can you compare '71, '74-78 data sets to OU 3 data set
and, if comparable, use the historical data to add more
power to OU 3 data set?

Phil & Phil Ryberg

OU 2 didn't follow flow chart agreed to. OU 2 used
a different flow chart.

Bonnie: Don't go through process & ID COCs and then say "well
these aren't COCs at OU 2 so they aren't COCs at OU 3."

Rocky Flats OU3 Background Data Survey

List of Background Data Sources

RME30181.X1.01

3/9/94

filename: sources.xls

SOURCE	MEDIA	PARAMETER(S)	STATUS
Arvada Dept. of Water and Environmental Quality	s. water	metals	entered
ASARCO Site (Globeville)	soil	metals	entered
Aurora Reservoir Water Quality Control	s. water	metals	reclaved
Bear Creek Water and Sanitation District	s. water	metals/rads	n/a
Boulder Dept. of Water and Environmental Quality	n/a	n/a	n/a
Broomfield Dept. of Water and Environmental Quality	n/a	n/a	n/a
California Gulch, Surface Water RI, Draft vol. 1, Woodward Clyde	s. water	metals	entered
Chatfield Basin Authority	s. water	metals	n/a
X Cherry Creek Basin Authority	X s. water/sediment	metals	entered
Colorado School of Mines	sediment	rads	entered
Colorado State University	X s. water/soil/sediment	metals/rads	pending
Coors Brewing Company	n/a	n/a	n/a
Denver Regional Council of Governments (DRCOG)	X s. water/sediment	metals/rads	entered
Historical Information Summary and Preliminary Health Risk Assessment: OU 3	X sediment	rads	entered
Interim Baseline Risk Assessment for the Sharon Steel/Midvale Tailings Site	n/a	n/a	n/a
Jefferson County Health Dept.	n/a	n/a	n/a
Last Chance Dam and Reservoir- Preliminary Feasibility Study	soils	metals	entered
Los Alamos Study - Pu in Northern NM and Southern CO, DOE, 1990	X soil, sediment	rads	entered
RFP Background Geochemical Characterization Report	s. water	metals/rads	entered
RFP OU3 Field Sampling Data - preliminary	X s. water/sediment	metals/rads	entered
Rocky Flats Program Unit	n/a	n/a	n/a
Rocky Flats Reading Room	s. water	rads	entered
Superfund Records Center - Broderick, Lowry, Denver Radium, Clear Creek	X s. water/sediment/soils	metals	entered
X U.S. Army Corps of Engineers	X s. water/sediment	metals/rads	pending
University of Colorado at Boulder	n/a	n/a	n/a
USGS Library	n/a	n/a	n/a
USGS Water Resources Division	n/a	n/a	n/a
Water Quality Control Division- STORET	s. water	metals	entered
Westminster Dept. of Water and Environmental Quality	n/a	n/a	n/a
Whiting Background Surface Soil Data - personal communication	soil	rads	entered

n/a - no available data from source

Rocky Flats OU3 Background Data Survey
 Reservoir Sediments Metals Concentrations in mg/kg
 RME30181.X1.01
 3/9/94
 filename: sediment.xls

*GWR → 50% from RFP
 standards → 50% from RFP
 Mower → 100%
 of H₂O from RFP*

*→ could use statistics
 but then w'd be
 doing a lot of
 BPT. to discount
 metals.*

Location	IHSS 200 - grab		IHSS 201 - grab		IHSS 202 - grab		GeoChem Report - stream		GeoChem Report - seep	
Chemical	N	mean	N	mean	N	mean	N	mean	N	mean
aluminum	43	10408	56	9475	19	13708	59	5887.61	20	10354.3
arsenic	43	5	56	6	19	5	59	2.41	20	12.55
barium	43	130	56	114	19	168	57	77.91	20	204.61
beryllium	43	0.64	56	0.59	17	0.97	57	0.66	16	1.13
cadmium	43	0.53	50	2	12	0.86	51	0.54	16	1.65
calcium	43	7539	56	9574	19	16655	59	3658.24	20	19407.5
cesium					13	20	56	69.29	17	260.47
chromium	43	9	56	10	19	14	59	8.13	18	10.98
cobalt	43	9	56	7	19	8	59	5.04	19	8.47
copper	43	42	56	59	19	18	59	10.15	18	18.74
iron	43	18530	56	15002	19	19742	59	8852.63	18	20763.89
lead	43	28	56	57	19	27	59	22.02	18	36.37
lithium	43	8	56	7	19	11	57	7.48	18	19.79
magnesium	43	2753	56	2662	19	3816	59	1473.77	20	2249.3
manganese	43	467	56	864	19	350	59	227.82	19	261.63
mercury			56	0.10	12	0.07	49	0.08	15	0.23
molybdenum			50	2	12	3	58	4.47	19	15.77
nickel	43	17	56	13	19	16	57	6.75	17	12.99
potassium	43	1468	56	1720	19	2560	58	835.34	18	1050.72
selenium	30	0.76	45	0.79	15	1.31	58	0.42	19	1.26
silicon	23	315	21	567	1	412	19	331.53	10	1698.7
silver	43	1.42	48	2	12	1.12	54	0.66	15	2.15
sodium	43	225	56	149	19	340	59	161.47	20	251.62
strontium	43	58	56	54	19	93	58	36.38	20	113.7
vanadium	43	32	56	25	19	42	57	18.33	19	27.63
zinc	43	180	56	424	19	73	58	43.77	20	56.13

*Could run statistics; compare
 data sets between Reservoirs -*

Note: • Source: Schaklette and Boerngen, 1984 *see if there are different
 populations or if they are
 the same (if the same ⇒ no RFP influence?)*

Rocky Flats OU3 Background Data Survey
Reservoir Sediments Metals Concentrations in mg/kg

RME30181.X1.01

3/9/94

filename: sediment.xls

N=1

Not Hgnd

Location	Soils of the Western U.S.*		Cherry Creek	Last Chance Ditch	Clear Creek - On-Site
Chemical	mean	range	lake bottom sediment	Soil sample levels	stream sediment
aluminum			96700		84-8400
arsenic	5.5	<0.1-97	5.57		1.1-46
barium	580	70-5000	591		
beryllium			4.03	1	
cadmium			<0.05	2.6	3.4-180
calcium					
cesium					
chromium	41	3.0-2000		17	2.8-140
cobalt			21.3		
copper	21	2-300	43.4	19	16-120
iron			49700		6630-46000
lead	17	<10-700	55	24	11-410
lithium					
magnesium					
manganese	380	30-5000	739		170-8000
mercury	0.046	<0.01-4.6	0.06		
molybdenum			22		
nickel	15	<5-700	26.2	24	5.3-190
potassium			15100		
selenium	0.23		1.1		
silicon					
silver	-	2.0-5.0	<0.05	0.6	1-180
sodium					
strontium			202		
vanadium			115		
zinc	55	10-2100	158	70	44-1600

Note: • Source: Schaklette and Boerngen, 1984

Rocky Flats OU3 Background Data Survey
 Reservoir Sediments Metals Concentrations in mg/kg
 RME30181.X1.01
 3/9/94
 filename: sediment.xls

Location	ASARCO-Globe	ASARCO-Globe	ASARCO-Globe	Broderick ROD
Chemical	SS Action Levels	Upper Bcknd Limit	Worker/Tres. Action Level	Trtmnt. Level
aluminum	70	28	426	5
arsenic				
barium				
beryllium				
cadmium	73		9125	1
calcium				
cesium				
chromium				
cobalt	500		3000	5
copper				
iron				
lead				
lithium				
magnesium				
manganese				
mercury				
molybdenum				
nickel				
potassium				
selenium				
silicon				
silver				
sodium				
strontium				
vanadium				
zinc				

Note: * Source: Schaklette and Boerngen, 1984

Rocky Flats OU3 Background Data Survey
 Reservoir Sediments Metals Concentrations in mg/kg
 RME30181.X1.01
 3/9/94
 filename: sediment.xls

Location	Lowry Background - stream sediment				Lowry Background - surface soils			
Chemical	N	mean	min	max	N	mean	min	max
aluminum	30	13959	1105	32100	21	16300	9100	22200
arsenic	26	5	0.90	17	20	5	1.10	11
barium	30	221	73	440	21	278	150	1050
beryllium	30	1.04	0.23	2	21	1.12	0.60	2.20
cadmium	30	1.04	0.20	4	21	0.77	0.22	1.90
calcium								
cesium								
chromium	30	12	2	23	21	17	9	25
cobalt	30	9	2	14	21	12	8	21
copper	30	18	3	48	21	21	13	48
iron								
lead	30	28	0.001	380	21	22	16	52
lithium								
magnesium								
manganese	21	605	402	1560	21	657	388	1090
mercury	30	0.08	0.05	0.29	21	0.07	0.05	0.21
molybdenum								
nickel	30	15	3	131	21	14	6	23
potassium								
selenium					21	0.69	0.11	1.30
silicon								
silver	14	2	0.31	4	21	0.47	0.06	0.80
sodium								
strontium								
vanadium	30	33	12	73	21	43	27	64
zinc	30	77	6	726	21	64	42	106

Note: * Source: Schaklette and Boerngen, 1984

Rocky Flats OU3 Background Data Survey
 Surface Soil Radionuclide Concentrations in pCi/g
 RME30181.X1.01
 3/9/94
 filename: surfsoil.xls

25 data pts

Location	IHSS-199 Soil Plots ^a				IHSS-199 (potentially outside RFP infl.) ^b			Rock Creek			
Radionuclide	N	mean	min	max	mean	min	max	N	mean	min	max
Am-241	57	0.038	-0.002	0.520	0.013	-0.002	0.041	16	0.019	-0.003	0.041
Pu-238					0.002	-0.002	0.007				
Pu-239											
Pu-239/240	61	0.177	0.008	2.950	0.030	0.007	0.122	20	0.054	0.026	0.100
U-233/234	60	1.023	0.530	2.140	1.032	0.541	2.390	15	1.154	0.922	1.472
U-235	60	0.049	0.013	0.124	0.047	-0.013	0.160	15	0.048	0.011	0.139
U-238	60	1.045	0.670	2.132	1.043	0.643	2.182	15	1.192	0.899	1.521

^a RFD+CDM Sampling Methods were averaged before subtraction.

^b RFP+CDM Sampling Methods not averaged

Note: Area of Influence based on figure presented by Whiting, 1994

Rocky Flats OU3 Background Data Survey
 Surface Soil Radionuclide Concentrations in pCi/g
 RME30181.X1.01

3/9/94

filename: surfsoil.xls

Location	Los Alamos Regional Study, 1990					Last Chance Ditch				
Radionuclide	N	mean	std dev	min	max	N	mean	std dev	min	max
Am-241	15	0.0007	0.0009	0.0001	0.0039	5	0.071	0.115	0	0.13
Pu-238										
Pu-239										
Pu-239/240										
U-233/234										
U-235	15	0.0144	0.0177	0.0012	0.081					
U-238										

1986 sampling event

1977 Sampling event: mean = 0.135
 Pu-239 (n = 6) min = 0.07
 max = 0.18

Rocky Flats OU3 Background Data Survey
 Surface Soil Radionuclide Concentrations in pCi/g
 RME30181.X1.01
 3/9/94
 filename: surfsoil.xls

Location	Myrick et al., 1982 - U.S.		Myrick et al., 1982 - Colo.		Myrick et al., 1982 - Rock Cr.		Whiting, 1994
Radionuclide	mean	std dev	mean	std dev	mean	std dev	range
Am-241							0 - 0.13 ^{0.08}
Pu-238							
Pu-239							
Pu-239/240							
U-233/234							
U-235							
U-238	1	0.83	1.2	0.91	1.18	0.19	

Rocky Flats OU3 Background Data Survey
Surface Soil Radionuclide Concentrations in pCi/g

RME30181.X1.01

3/9/94

filename: surfsoil.xls

Location	Lowry Background			
Radionuclide	N	mean	min	max
Am-241	9	0.067	0.05	0.1
Pu-238				
Pu-239				
Pu-239/240	1	0.048	0.048	0.048
U-233/234	1	1.2	1.2	1.2
U-235	10	0.261	0.055	0.3
U-238	1	1.3	1.3	1.3



MEETING NOTES

PROJECT NUMBER

SHEET 1 OF 17

NOTES ISSUED BY

REGION

DATE

SUBJECT: RFP EA STATUS

MEETING

DATE: 2/14/94

LOCATION EG&G

ATTENDEES:

SEE ATTACHED LIST

NOTES BY: KAREN WIEMELT / CH2M HILL

REGION

TOPICS DISCUSSED

ACTION/NOTES

COC SELECTION

1. Topic - There is not a good background source for Reservoir SW and sediment.

Action - EPA and CDH will talk to get more CDH and Milt hammering EPA and others to get resolution on what source to use by Fri. 2/18/94

2. Topic - There is also a problem with the background source for cores. However, purpose of cores is nature & extent; there is probably not an exposure pathway for subsurface core.

Action - If core data is not assoc. w/ an exposure pathway, the data does not need to be compared to bkgrd data for risk assessment.

Note: Same applies to soil trenches, esp. since most contamination is at the surface. Trench info will be used for nature & extent. If any comparisons are done, use borehole bkgrd data.

TOPICS DISCUSSED

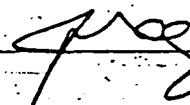
ACTION/NOTES

3. Topic - GW data would be compared to UTLs since we're not seeing any hits. EPA/CDH did not require the wells as part of the work plan development. The wells were installed in case the public asked whether the GW had been investigated.

Action - Comparison to UTLs is acceptable for GW since it is not an exposure pathway. EG&G will look at data and confirm there's no problem.

1. Topic - Are these flowcharts the most recent?

DOE'S
Action - Will use ~~flowcharts~~ strawman + EPA comment.

Len Pope (left meeting 11:30) 

GWR - EXPOSURE SCENARIOS

1. Topic - Will GWR be drained or left intact or partially drained?

Action - EG&G will look at current scenario and will also look at a most conservative approach (i.e., GWR drained). DOE is going to work with Broomfield to understand what they want to see done w/ GWR.



MEETING NOTES

PROJECT NUMBER

PAGE 3 OF 5 19

NOTES ISSUED BY

REGION

DATE

SUBJECT:

MEETING

DATE:

LOCATION

ATTENDEES:

NOTES BY:

REGION

TOPICS DISCUSSED

ACTION/NOTES

DRINKING H₂O SUPPLY

1. Topic - We had some conversations at previous mgs on what data set do we use for drinking water source - untreated or treated.

Action - Since it is an existing water supply, for drinking water scenario, we will use treated water. For recreational we'll use untreated water.

2. Topic - What about for agricultural use?

Action - If addressed qualitatively, thorough explanation must be provided.

3. Topic - Drinking water scenario will be used for which Reservoirs?

Action - Standley and GWR. Irrigation will be used for Mowers.

PV RESULTS

1. Topic - Presented PV results for soil and sed - see maps. No action

TML NO. 1

1. Topic - Faxed Responses to TML No. 1 to EPA previously.

EPA concern on Comment 1A was, if we didn't get enough samples in a given drainage, do we have enough data?

Action - It depends on data aggregation.

1. Topic - Was nearshore sediment sampling conducted during high or low water levels?

Action - GWR was sampled during low water levels. Standley was sampled right after when water was beginning to rise. EE&C stopped and sampled later in the summer when water level was down. The Response is incorrect and will be Revised.

Topic - Seasonality typically affects EE; however, at ou 3, the systems are impacted primarily by management practices. Further Woman Creek is diverted from GWR most of the time.

Action - EPA and CSH will defer commenting until EE mtg (2/25)



MEETING NOTES

PROJECT NUMBER

SHEET 5 OF 5

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NOTES BY:

REGION

TOPICS DISCUSSED

ACTION/NOTES

3. Action - cont

DOE will formally submit to EPA/CDH EPA/CDH
will send final approval letter. EG&G
will attach to TM No. 1 for document
control.

EPA

CDH

Dave Norbury

DOE

For JBN Paper

EG&G

<u>Name</u>	<u>Affiliation</u>	<u>Phone</u>
Dennis Smith	CH2M Hill	9771-0952
Mike Bedan	CH2M Hill	771-0952 X 2498
Edo Kray	COH/RCO	966-2115
KAREN WIEMELT	CH2M Hill	771-0952
Susan GRIFFIN	EPA	X 2392
Robert DeGrandchamp	FRC	294-1062
Bonnie LANEUE	EPA	295-110
Jer Pepe	DOE	294-1067
Michael Guillaume	DOE/Aguirre	966-2184
Rick Roberts	EEEG	966-4208
Dave Norbury	CIDH	966-8508
Mark Budd	EEEG	692 3415
		466-8519

Meeting Agenda
February 14, 1994
Operable Unit 3

- 1) COC Selection Process
 - Background comparison
 - IHSS by IHSS
 - Media background comparisons
 - Risk Assessment COC flow chart
- 2) Pu - surficial soils, sediments, surface water
 - GIS plots
 - Mean + 2sd
 - $>10^{-6}$ risk
- 3) Exposure scenario definition for water intake
 - Water treatment plant?
- 4) Exposure scenario definition for Great Western Reservoir
 - Is the cup half empty or half full?
- 5) Technical Memorandum Number 1
 - Comment resolution

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Agenda
PCOC Identification Working Session
EPA/CDH/DOE/EG&G
May 3, 1994

Meeting Objectives

- Update EPA/CDH on PCOC approach
- Share preliminary statistical results

Gilbert Results

- Soils
- Groundwater
- Surface water
- Sediments

Overview of Weight-of-Evidence

- Interpretative rationale based on all weights-of-evidence
- Semi-quantitative evaluations
- OU 3 data set comparisons
- Investigate anomalies
- Geochemical evaluations
- Physical processes
- Spatial analysis
- Measurement variability
- Conceptual model

Example Application of Approach

- Groundwater
- Surface Water
- Sediments

Discussion

*Compare levels to
Chemical-sp
PRGs
Ag < PEG, don't incl
in R.A.
CONTOURS (app. reviewed &
approved at PEG*

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PCOC Identification Working Session
May 3, 1994

SURFACE SOIL

- Gilbert Statistical Evaluations Performed
 - Americium-241 and plutonium-239/240 are PCOCs based on statistical tests
 - UTL, Slippage, Quantile, and Gehan tests for americium-241
 - UTL, Slippage, Quantile, Gehan, and t tests for plutonium-239/240
 - One UTL exceedance for uranium-233/234 (sample location=PT17992); one UTL exceedance for uranium-238 (sample location=PT17992)
- PT17992 located approximately 6 miles from the Rocky Flats Plant; not included within the Remedy Acreage boundaries - SE OF STANLEY LAK
- Uranium-233/234: UTL = 1.86 PCI/G; Exceedance = 2.39 PCI/G
- Uranium-238: UTL = 2.00 PCI/g; Exceedance = 2.19 PCI/G

Test Results for OU 3 Remedy Acreage Surface Soil Data

4

CHEMICAL		UTLTEST	SLIPPAGE	DETECTB	QUANTILE	GEHAN	TTEST	PCOC
AMERICIUM-241	PCI/G	yes	yes		no	no	no	yes
PLUTONIUM-239/240	PCI/G	yes	yes		yes	yes	no	yes
URANIUM-233/234	PCI/G	no	no		no	no	no	no
URANIUM-235	PCI/G	no	no		no	no	no	no
URANIUM-238	PCI/G	no	no		no	no	no	no

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Test Results for OU 3 Plus Jeffco Surface Soil Data

7

CHEMICAL		UTLTEST	SLIPPAGE	DETECTB	QUANTILE	GEHAN	TTEST	PCOC
AMERICIUM-241	PCI/G	yes	yes		yes	yes		yes
PLUTONIUM-239/240	PCI/G	yes	yes		yes	yes	yes	yes
URANIUM-233/234	PCI/G	yes	no		no	no		yes
URANIUM-235	PCI/G	no	no		no	no		no
URANIUM-238	PCI/G	yes	no		no	no		yes

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Test Results for OU 3 Surface Soil Data

4

CHEMICAL		UTLTEST	SLIPPAGE	DETECTB	QUANTILE	GEHAN	TTEST	PCOC
AMERICIUM-241	PCI/G	yes	no		no	no		yes
PLUTONIUM-239/240	PCI/G	yes	yes		yes	no	yes	yes
URANIUM-233/234	PCI/G	yes	no		no	no		yes
URANIUM-235	PCI/G	no	no		no	no		no
URANIUM-238	PCI/G	yes	no		no	no		yes

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Test Results for OU 3 Remedy Acreage Plus Jeffco Surface Soil Data

7

CHEMICAL	UTLTEST	SLIPPAGE	DETECTB	QUANTILE	GEHAN	TTEST	PCOC
AMERICIUM-241	PCI/G	yes	yes	yes	yes		yes
PLUTONIUM-239/240	PCI/G	yes	yes	yes	yes	yes	yes
URANIUM-233/234	PCI/G	no	no	no	no	no	no
URANIUM-235	PCI/G	no	no	no	no	no	no
URANIUM-238	PCI/G	no	no	no	no	no	no

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Test Results for OU 3 Minus Remedy Acreage Surface Soil Data

4

CHEMICAL		UTLTEST	SLIPPAGE	DETECTB	QUANTILE	GENAN	TTEST	PCOC
AMERICIUM-241	PCI/G	yes	no		no	no		yes
PLUTONIUM-239/240	PCI/G	yes	yes		no	no	yes	yes
URANIUM-233/234	PCI/G	yes	no		no	no		yes
URANIUM-235	PCI/G	no	no		no	no		no
URANIUM-238	PCI/G	yes	no		no	no		yes

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PCOC Identification Working Session
May 3, 1994

GROUNDWATER

- Gilbert Statistical Evaluations Not Performed
 - Only two OU 3 well locations
 - Nine rounds of sampling from each well
 - Major-ion chemistry indicates no direct comparison to background well groupings
 - Based on conceptual model, groundwater is not a primary pathway
 - Purpose of data collection was to characterize site-specific hydrogeology and interaction between reservoirs and groundwater
- Use Weight-Of-Evidence Approach

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PCOC Identification Working Session
May 3, 1994

SURFACE WATER STREAMS

- Gilbert Statistical Evaluations not performed
 - Insufficient sample locations due to intermittent nature of streams (3 sample locations)
 - Eight total metal/radionuclide samples when data sets combined for all IHSS
 - Three dissolved metal/radionuclide samples when data sets combined for all IHSS
- Use Weight-of-Evidence Approach

SURFACE WATER RESERVOIRS

- Gilbert Statistical Evaluation not performed
 - No appropriate background data set for reservoirs
- Use Weight-of-Evidence Approach

PCOC Identification Working Session
May 3, 1994

RESERVOIR SEDIMENTS

- Gilbert Statistical Evaluation was not performed
 - An appropriate background data set is not available
- Use Weight-of-Evidence Approach

STREAM SEDIMENTS

- Gilbert Statistical Evaluation was performed
 - Data was combined over IHSSs (too few data points in IHSS 201 [n=7] and IHSS 202 [n=4] streams)
 - Plutonium-239/240 and Americium-241 are statistical PCOCs
 - 20 of 26 metals are statistical PCOCs
- Use Weight-of-Evidence Approach

Test Results for OU 3 Stream Sediment (grab) Data

CHEMICAL		UTLTEST SLIPPAGE DETECTB QUANTILE GEHAN TTEST PCOC							
TOTAL	ALUMINUM	MG/KG	no	no		no	yes	yes	yes
TOTAL	AMERICIUM-241	PCI/G	no	no		no	yes	no	yes
TOTAL	ANTIMONY	MG/KG	no	no			yes	yes	yes
TOTAL	ARSENIC	MG/KG	no	no		yes	yes	yes	yes
TOTAL	BARIUM	MG/KG	no	no		yes	yes	yes	yes
TOTAL	BERYLLIUM	MG/KG	no	no			yes	yes	yes
TOTAL	CAESIUM	MG/KG	yes	no	U		yes	yes	yes
TOTAL	CALCIUM	MG/KG	yes	yes		yes	yes	yes	yes
TOTAL	CESIUM	MG/KG	no	no			no		no
TOTAL	CESIUM-137	PCI/G	no	no		no	no		no
TOTAL	CHROMIUM	MG/KG	no	no			no		no
TOTAL	COBALT	MG/KG	yes	no	U		yes		yes
TOTAL	COPPER	MG/KG	no	yes			yes		yes
TOTAL	GROSS ALPHA	PCI/G	no	no		no	no	no	no
TOTAL	GROSS BETA	PCI/G	no	no		no	no	no	no
TOTAL	IRON	MG/KG	no	no		yes	yes	yes	yes
TOTAL	LEAD	MG/KG	no	no		yes	yes	no	yes
TOTAL	LITHIUM	MG/KG	no	no			yes	yes	yes
TOTAL	MAGNESIUM	MG/KG	no	no		yes	yes	yes	yes
TOTAL	MANGANESE	MG/KG	yes	yes		yes	yes	yes	yes
TOTAL	MOLYBDENUM	MG/KG	no	no			yes		yes
TOTAL	NICKEL	MG/KG	no	yes		yes	yes		yes
TOTAL	PLUTONIUM-239/240	PCI/G	no	no		yes	no	no	yes
TOTAL	POTASSIUM	MG/KG	no	no		yes	yes		yes
TOTAL	RADIUM-226	PCI/G	no	no		no	yes	no	yes
TOTAL	RADIUM-228	PCI/G	no	no		no	no	no	no
TOTAL	SELENIUM	MG/KG	no	no			no		no
TOTAL	SILICON	MG/KG	no	no		yes	yes	yes	yes
TOTAL	SILVER	MG/KG	yes	no	U		yes		yes
TOTAL	SODIUM	MG/KG	yes	no	U		yes		yes
TOTAL	STRONTIUM	MG/KG	no	no			yes	yes	yes
TOTAL	STRONTIUM-89/90	PCI/G	no	no		no	no		no
TOTAL	TRITIUM	PCI/L	yes	no		no	no		yes
TOTAL	URANIUM-233/234	PCI/G	no	no		no	no	no	no
TOTAL	URANIUM-235	PCI/G	no	no		no	no	no	no
TOTAL	URANIUM-238	PCI/G	no	no		no	no	no	no
TOTAL	VANADIUM	MG/KG	no	no		no	yes	yes	yes
TOTAL	ZINC	MG/KG	yes	yes		yes	yes	yes	yes
VOA-ORG-CLP	TOLUENE	UG/KG	yes	no			yes		yes
VOA-ORG-CLP	TOTAL XYLENES	UG/KG	no	no			no		no
VOA-ORG-CLP	TRICHLOROTRIFLUOROETHANE	UG/KG	no	no					no
WATER-QUALITY	% SOLIDS	%	no	yes		no	yes		yes
WATER-QUALITY	TOTAL ORGANIC CARBON	%	no	no					no

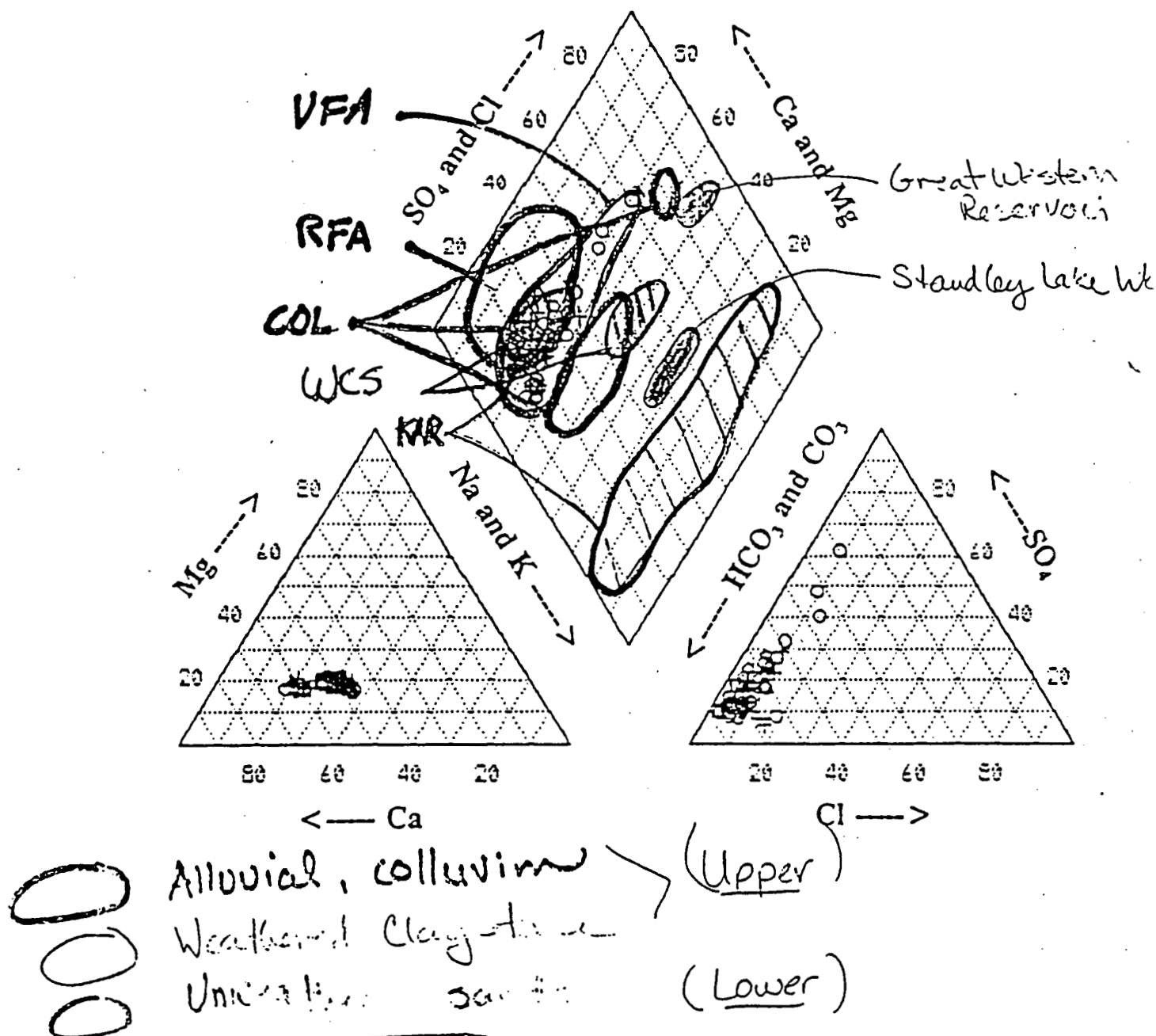
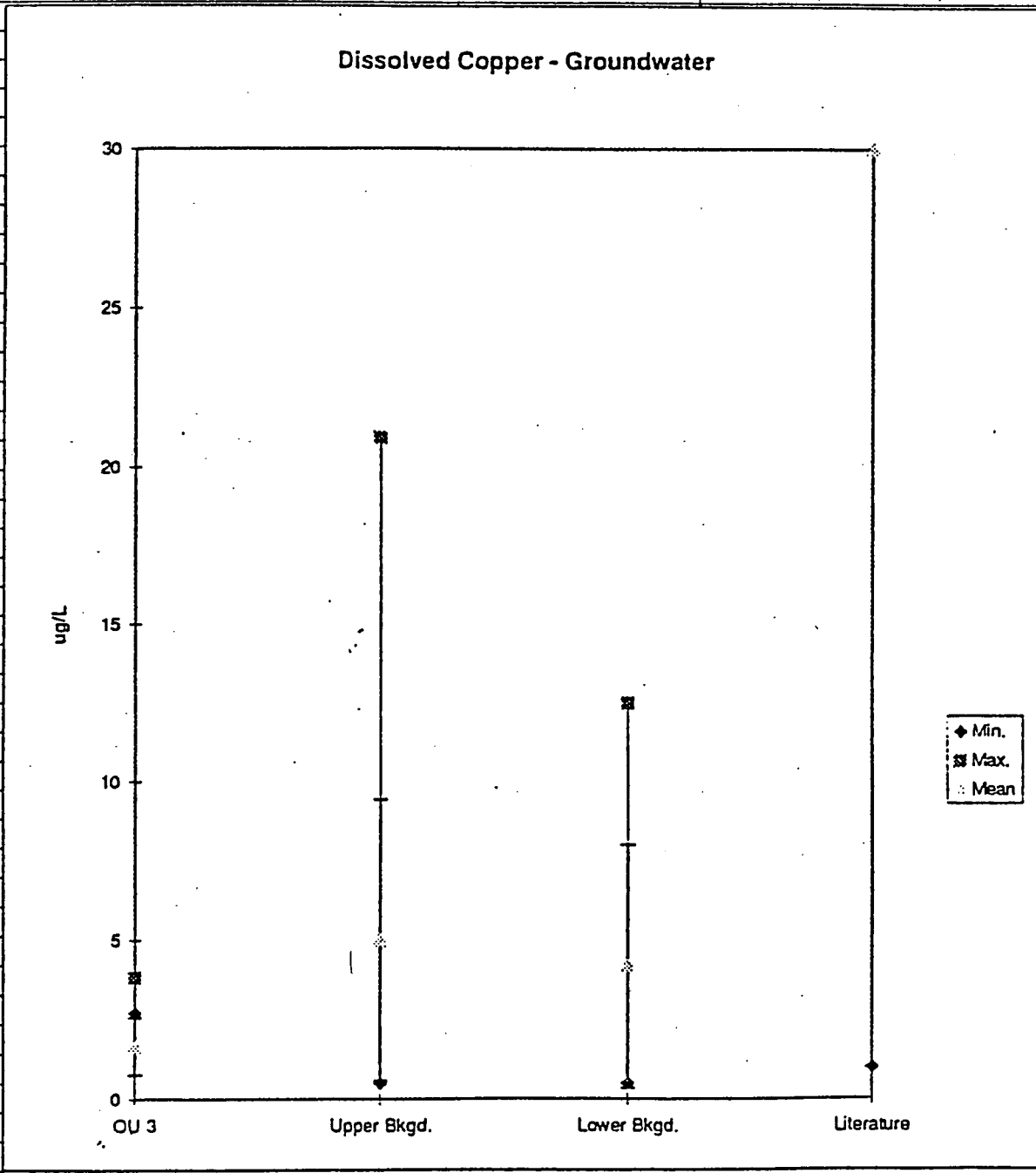


Figure 5-6. Piper diagram showing major-ion chemistry of groundwater from VFA. Concentrations of major ions (as meq/L) are given as percentages of the total milliequivalents per liter.

PCOC Evaluation Groundwater

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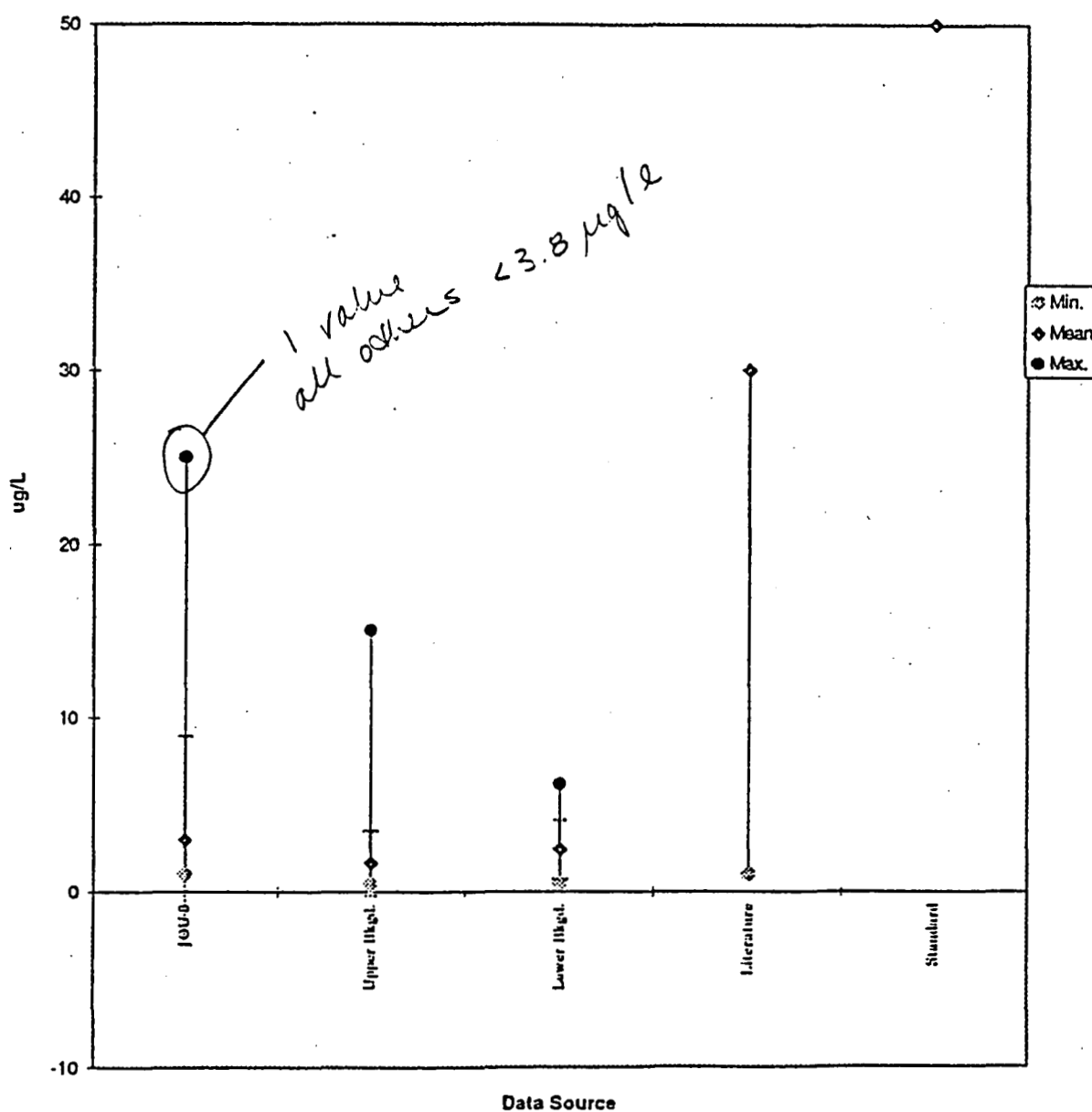
Dissolved Copper in Groundwater					
ug/L					
Data	Min.	Max.	Mean	Std. Dev.	Source
OU 3	2.7	3.8	1.656	0.888	DA042694.db (RFEDS - 4/94)
Upper Bkgd.	0.5	20.9	5.01	4.42	Background Geochemical Characterization Report
Lower Bkgd.	0.5	12.5	4.17	3.83	Background Geochemical Characterization Report
Literature	1		30		
Standard			1000		



PCOC Evaluation Groundwater

Dissolved Arsenic in Groundwater					
ug/L					
Data	Min.	Mean	Max.	Std. Dev.	Source
OU 3	1	2.975	25	5.954	DA042594.db (RFEDS - 4/94)
Upper Bkgd.	0.4	1.63	15	1.84	Background Geochemical Characterization Report
Lower Bkgd.	0.4	2.41	6.2	1.7	Background Geochemical Characterization Report
Literature	1	30			
Standard		50			

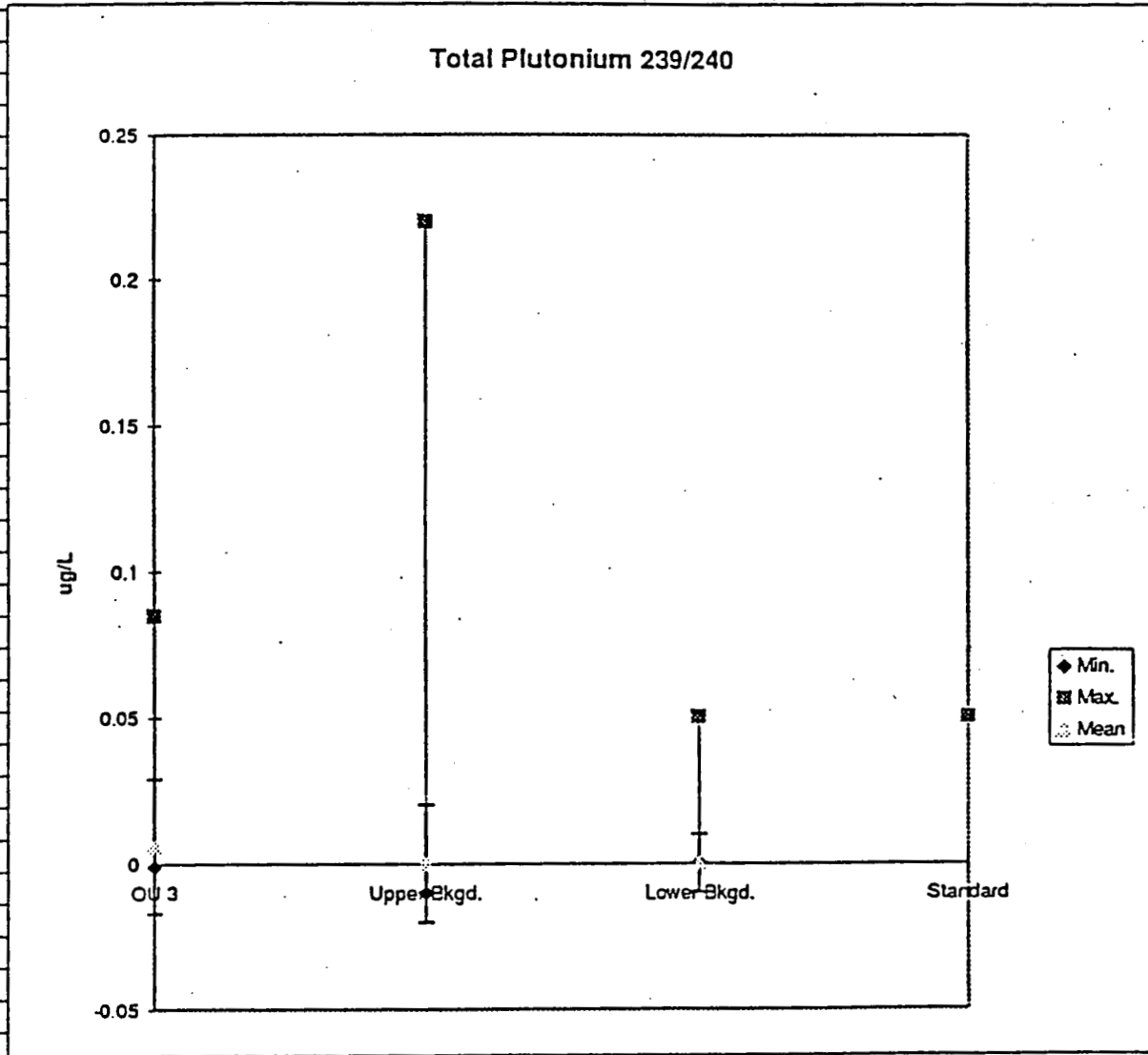
Dissolved Arsenic - Groundwater



PCOC Evaluation Groundwater

34

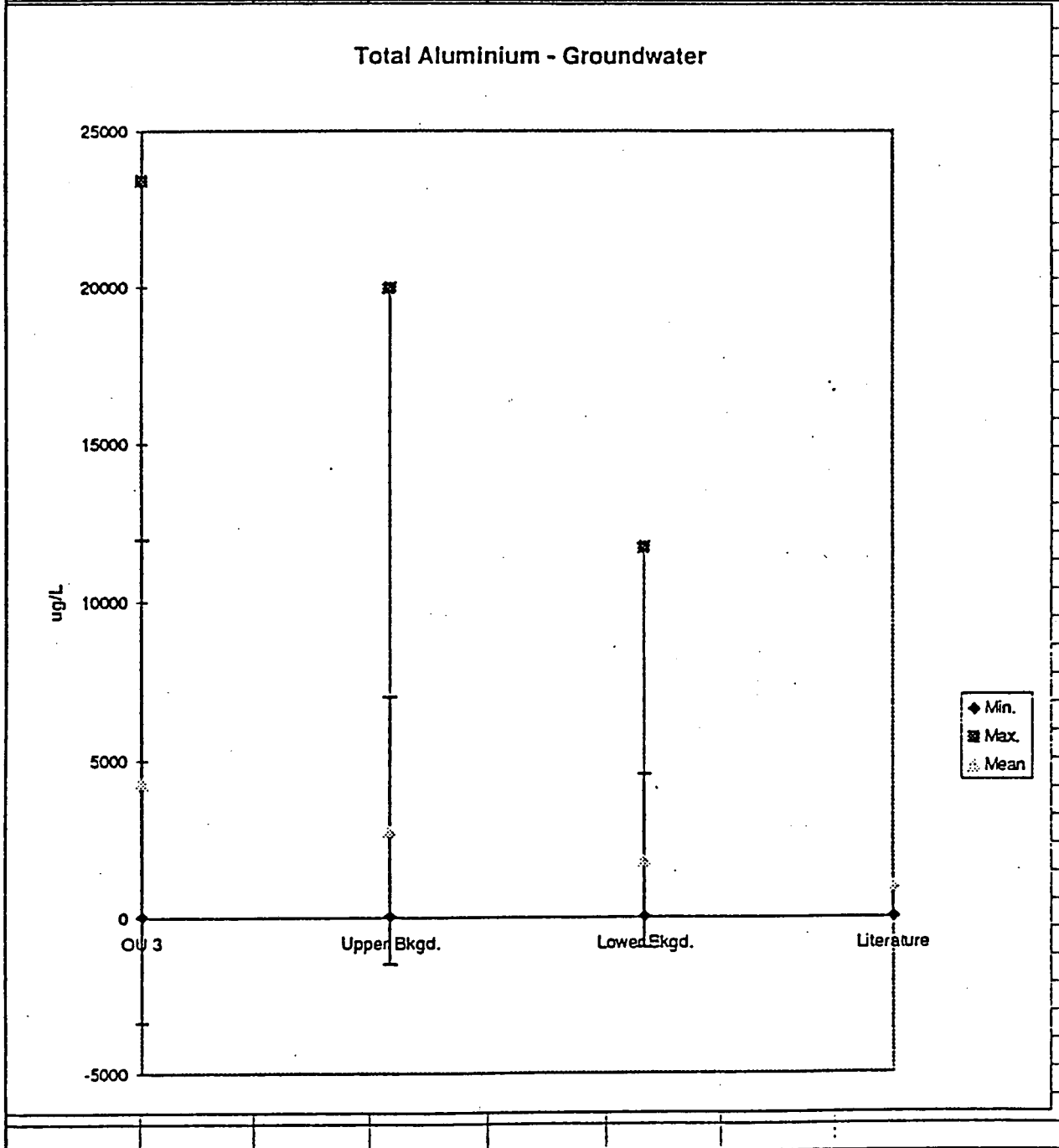
Total Plutonium 239/240 in Groundwater					
ug/L					
Data	Min.	Max.	Mean	Std. Dev.	Source
OU 3	-0.001	0.085	0.006	0.023	DA042694.db (RFEDS - 4/94)
Upper Bkgd.	-0.01	0.22	0	0.02	Background Geochemical Characterization Report
Lower Bkgd.	0	0.05	0	0.01	Background Geochemical Characterization Report
Standard			0.05		



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PCOC Evaluation Groundwater

Total Aluminium in Groundwater					
ug/L					
Data	Min.	Max.	Mean	Std. Dev.	Source
OU 3	28.2	23400	4286	7675	DA042694.db (RFEDS - 4/94)
Upper Bkgd.	22.6	19950	2743	4249	Background Geochemical Characterization Report
Lower Bkgd.	11	11700	1791	2773	Background Geochemical Characterization Report
Literature	5		1000		
Standard					



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PCOC Evaluation - Groundwater

Test Group	Parameter	Unit	# of Data	# of Samples	Min. Non-detect	Max. Non-detect	Min. Detect	Mean	Stand. Dev.	Coeff. of Var.	Upper Geo. Chem. Min	Upper Geo. Chem. Max	Upper Geo. Chem. Mean	Std. Dev.	Min. Lower Geo	Max. Lower Geo	Mean Lower Geo	Std. Dev.	Min (Range)	Max (Range)	Other	OU 3 mean/Upper mean	OU 3 mean/Lower mean	Standard (t)	Comments		
TR-METAL	ANTHRACENE	UOL	1	16	6%	13	36	27.5	27.5	11.875	3.789	0.488	3.6	86.6	19.19	12.83	3.3	41.3	13.63	10.4		NA	0.61	0.81		OU 3 mean less than background and within range	
TR-METAL	ARSENIC	UOL	10	16	43%	17	3	2.3	6.9	2.759	1.647	0.597	0.35	5	1.95	1.71	0.35	7	2.76	2.02		17.9 mean, 0.01-	1.41	1.0		OU 3 mean less than background and within range	
TR-METAL	BARITUM	UOL	16	16	100%			39.3	164	54.666	47.581	0.837	25.9	317	102.44	45.37	61.3	303	113.95	51.97		30	500		OU 3 mean less than background and within range		
TR-METAL	BERYLLIUM	UOL	4	16	33%	1	1	1.1	1.6	0.704	0.877	0.548	0.4	4.8	1.07	0.87	0.3	2.3	0.86	0.74		10	10		OU 3 mean less than background and within range		
TR-METAL	CADMIUM	UOL	1	16	6%	2	4	2.8	2.8	1.580	0.810	0.329	0.3	11.1	1.64	1.29	0.3	3.5	1.45	0.75		<10	<10		OU 3 mean less than background and within range		
TR-METAL	CALCIUM	UOL	16	16	100%			82.00	370.000	201612.500	117815.222	0.584	15950	186000	55020.23	31667.78	10800	91900	36382	2581.47		<500000				Piper diagram indicate GWA well is calcium enriched. Maximum values within literature range.	
TR-METAL	CELESTINE	UOL	2	13	15%	12	1	25	50	16.508	12.138	0.736	2	500	154.42	198.79	2	500	131.59	175.16		NA				OU 3 mean less than background and within range	
TR-METAL	CHROMIUM	UOL	6	16	38%	3	5	2.5	29	6.428	8.939	1.390	1	31.63	7.01	6.68	1	21.4	5.23	4.61		<1				OU 3 mean less than background and within range	
TR-METAL	COBALT	UOL	4	16	23%	3	6	5.3	16.6	4.331	4.981	1.061	1	39.4	7.64	9.67	1	25	5.25	8.16		<10	10			OU 3 mean less than background and within range	
TR-METAL	COPPER	UOL	10	16	43%	2	4	4.4	39.7	9.194	12.019	1.307	1	105	10.67	12.21	1	125	11.99	21.82		<1	30			OU 3 mean less than background and within range	
TR-METAL	IRON	UOL	16	16	100%			753	27100	6216.750	9564.311	1.534	6.3	27100	3017.34	4994.5	9.8	16900	2359.92	3697.44		10	10000			OU 3 mean less than background and within range	
TR-METAL	LEAD	UOL	8	16	50%	1	2	1.7	20.1	4.331	6.418	1.486	0.3	25	3.26	3.64	0.3	17.7	3.82	4.29		<15	15			OU 3 max within range of background max.	
TR-METAL	LITHIUM	UOL	16	16	100%			72.3	448	247.978	180.476	0.729	1.1	266	33.75	48.76	6.2	106	40.69	29.29		1	150			Mean less than background but greater than literature.	
TR-METAL	MAGNESIUM	UOL	16	16	100%			39700	97700	51287.500	31378.038	0.610	2230	47900	10315.64	7956.43	19500	19700	6679.46	5030.81		<400000	400000			Piper diagram indicate Sundley Lake well is magnesium enriched. Maximum values within literature range.	
TR-METAL	MANGANESE	UOL	16	16	100%			52.8	949	372.481	268.916	0.986	0.5	584	79.59	108.18	1	710	61.87	125.21		<1	1000	1000			OU 3 maximum is less than literature maximum.
TR-METAL	MERCURY	UOL	0	16	0%	0.2	0.2																			No detects in OU 3	
TR-METAL	MOLYBDENUM	UOL	1	16	6%	4	16	10.2	10.2	5.175	2.386	0.443	1	100	24.09	39.47	1	100	18.59	33.45		<1	30			OU 3 mean less than background and within range	
TR-METAL	NICKEL	UOL	2	16	13%	5	33.1	24	30.3	7.897	8.311	1.082	1	71.6	10.38	9.49	1	24.3	8.7	7.25		<10	50			OU 3 mean less than background and within range	
TR-METAL	POTASSIUM	UOL	15	16	94%	4090	4090	3210	14800	7677.813	4562.519	0.594	2.9	8270	1731.21	1176.59	516	6870	2846.38	1725.69		1000	10000			Piper diagram indicate Sundley Lake well is potassium enriched. Maximum values within literature range.	
TR-METAL	SELENIUM	UOL	2	16	13%	1	10	1.6	1.6	1.513	1.415	0.915	0.3	203	4.57	18.64	0.3	2.3	1.19	0.63		<1	10			OU 3 mean less than background and within range	
TR-METAL	SILICON	UOL	16	16	100%			5110	53400	14510.000	15678.855	1.081	4399	13650	15564.97	10797.33	3720	25900	9427.3	6631.12		5000	100000			OU 3 mean less than background and within range	
TR-METAL	SILVER	UOL	0	16	0%	3	5																			No detects in OU 3	
TR-METAL	SODIUM	UOL	16	16	100%			258000	533000	276437.500	119524.039	0.318	2500	194000	30081.85	40019.17	11500	434000	139228	13404.33		<1000000	1000000			Piper diagram indicate Sundley Lake well is calcium enriched. Maximum values within literature range.	
TR-METAL	STRONTIUM	UOL	16	16	100%			1090	5590	3016.751	1948.048	0.646	38.1	1770	312.61	271.09	100	1170	399.78	312.58		100	4000			Values greater than background and literature.	
TR-METAL	THALLIUM	UOL	0	16	0%	1	4																			No detects in OU 3	
TR-METAL	TIN	UOL	2	16	13%	10	29	38.4	47.3	12.469	12.574	0.993	4.7	100	33.88	35.33	4.7	100	27.46	31.18		<200	200			OU 3 mean less than background and within range	
TR-METAL	VANADIUM	UOL	4	16	23%	2	14	6.2	70.3	14.471	23.321	1.612	1	123	13.81	14.09	0.5	46.7	10.43	11.25		<1	10			OU 3 maximum less than background maximum.	
TR-METAL	ZINC	UOL	11	16	69%	2	12.6	9.5	158	35.073	49.359	1.407	4.2	498	37.16	49.8	5	189	32.45	51.31		<10	2000			OU 3 mean less than background and within range	
TRAOS	AMERICAN-21	PCOL	8	14	57%	0	0.011	0.001214	0.01	0.0081	0.0044	0.775	-0.01	0.1	0.01	0.01	0	0.1	0.01	0.02						OU 3 mean less than background and within range	
TRAOS	PLUTONIUM-239/240	PCOL	5	14	36%	-0.013	0.001	-0.00101	0.008	0.0061	0.023	3.601	-0.01	0.22	0	0.02	0	0.05								Only one outlier value that is an anomaly. Subsequent results from that well are low.	
TRAOS	URANIUM-235/234	PCOL	3	4	100%	0	0	0.64	4.6	2.378	1.391	0.813	0	164	13.62	38.75	0.15	1.52	0.77	0.57						OU 3 mean less than background and within range	
TRAOS	URANIUM-235	PCOL	3	4	75%	0	0	0.003	0.2	0.101	0.0031	0.824	-0.02	6.29	0.62	1.38	0	0.04	0.03	0.02						OU 3 mean less than background and within range	
TRAOS	URANIUM-238	PCOL	4	4	100%			0.7	4.2	1.978	1.4051	0.812	0	108	10.84	27.73	0.17	0.53	0.33	0.26						OU 3 mean less than background and within range	

PCOC Evaluation - Groundwater

Test Group	Parameter	Unit	# of Districts	# of Samples	Freq. of District	Min. Nearest	Min. Nearest	Min. District	Min.	Stand. Dev.	Cent. of Var	Upper One Class Min	Upper One Class Max	Upper One Class Mean	Std. Dev.	Min Lower One	Min Lower One	Mean Lower One	Std Dev.	Min (Region)	Min (Region)	Other	OU 3 mean/Upper mean	OU 3 mean/Lower mean	Standard (1)	Comments	
WQ	BICARB AS CAOD	MG/L	16	16	100%				230	480	408.188	61.128	0.150	46.9	756	224	151.72	63	234	102.98			1.8	1.7		Upper diagrams indicate bicarbonate enriched waters at Stanley Lake.	
WQ	CAOB AS CAOD	MG/L	4	16	25%	0.71	1.1	1.1	1.1	1.1	1.1	1.1	1.1	0	32	1.825	3.48	0	4.2			0.6	0.3		OU 3 mean less than background and within range		
WQ	CHLORIDE	MG/L	16	16	100%				14.69		63.399	35.742	0.564	1.2	118	12.2	12.93	1.6	100	128.1			52	0.6		OU 3 mean less than background and within range	
WQ	FLUORIDE	MG/L	16	16	100%	0.26	0.26	0.26	0.26		0.622	0.330	0.501	0.1	2.9	0.611	0.472	0.17	2	0.949	0.465		1.0	0.7		OU 3 mean less than background and within range	
WQ	NITRATE/NITRITE	MG/L	9	16	56%	0.02	0.069	0.027	0.027		0.158	0.308	1.318	0.01	12	1.048	1.81	0.01	3.6	0.861	0.945		0.2	0.2		OU 3 mean less than background and within range	
WQ	SULFATE	MG/L	16	16	100%				340	3800	1239.944	968.211	0.787	2.9	1200	86	174.61	124	250.87	445.29		143	99		Upper diagrams indicate sulfate enriched waters at GWR.		
WQ	TDS	MG/L	16	16	100%				1000	3183	1033.506	1005.551	0.434	66	1580	355	312.01	120	1700	445.29		57	3.71		Water quality parameters, not a CQC		
WQ	OU 3 mean less than background and within range								6	1200	223.647	412.103	1.843	2	6400	133	429.32	3	4600	403		1.7	0.61		OU 3 mean less than background and within range		
(1) Colorado Basin Standards - (dev) - drinking water, (sec) - secondary, (ag) - agricultural																											
(a) Boyle et al																											
(b) Lowry Landfill background data																											

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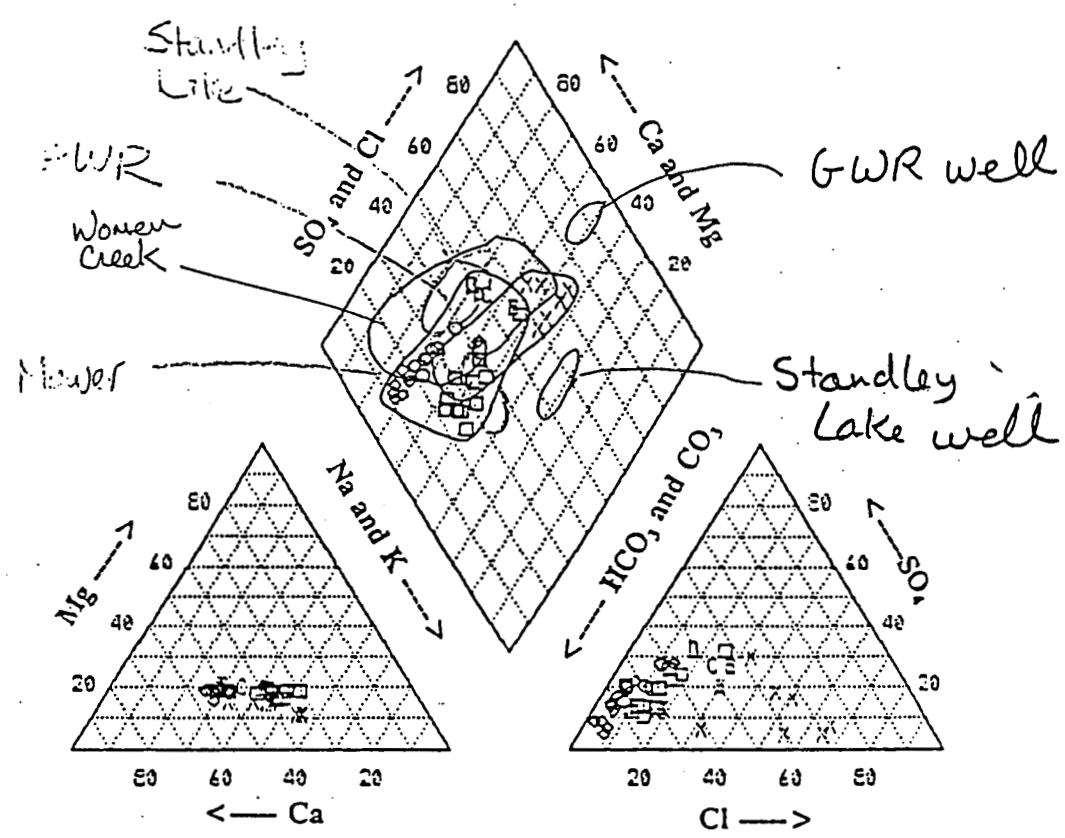
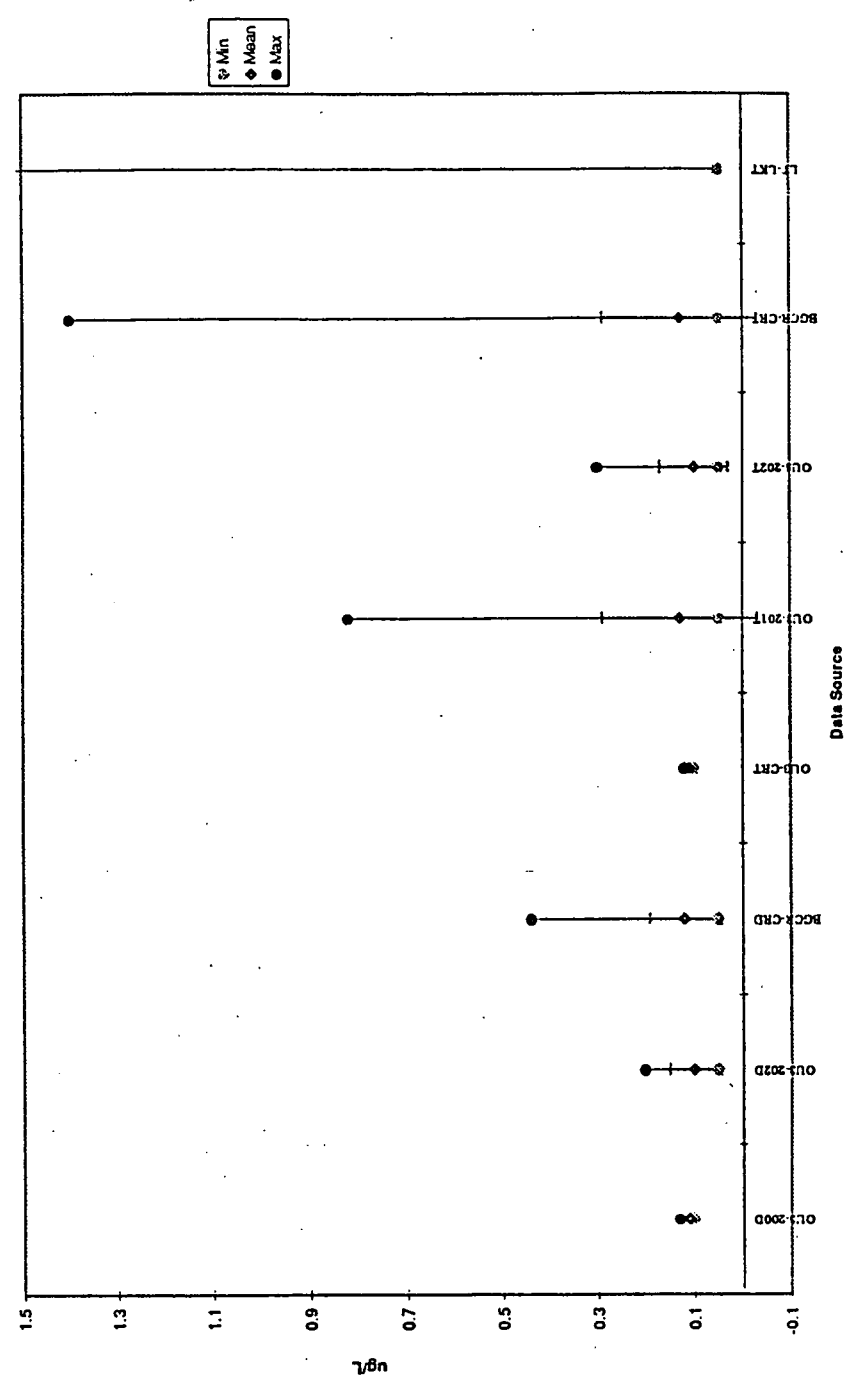


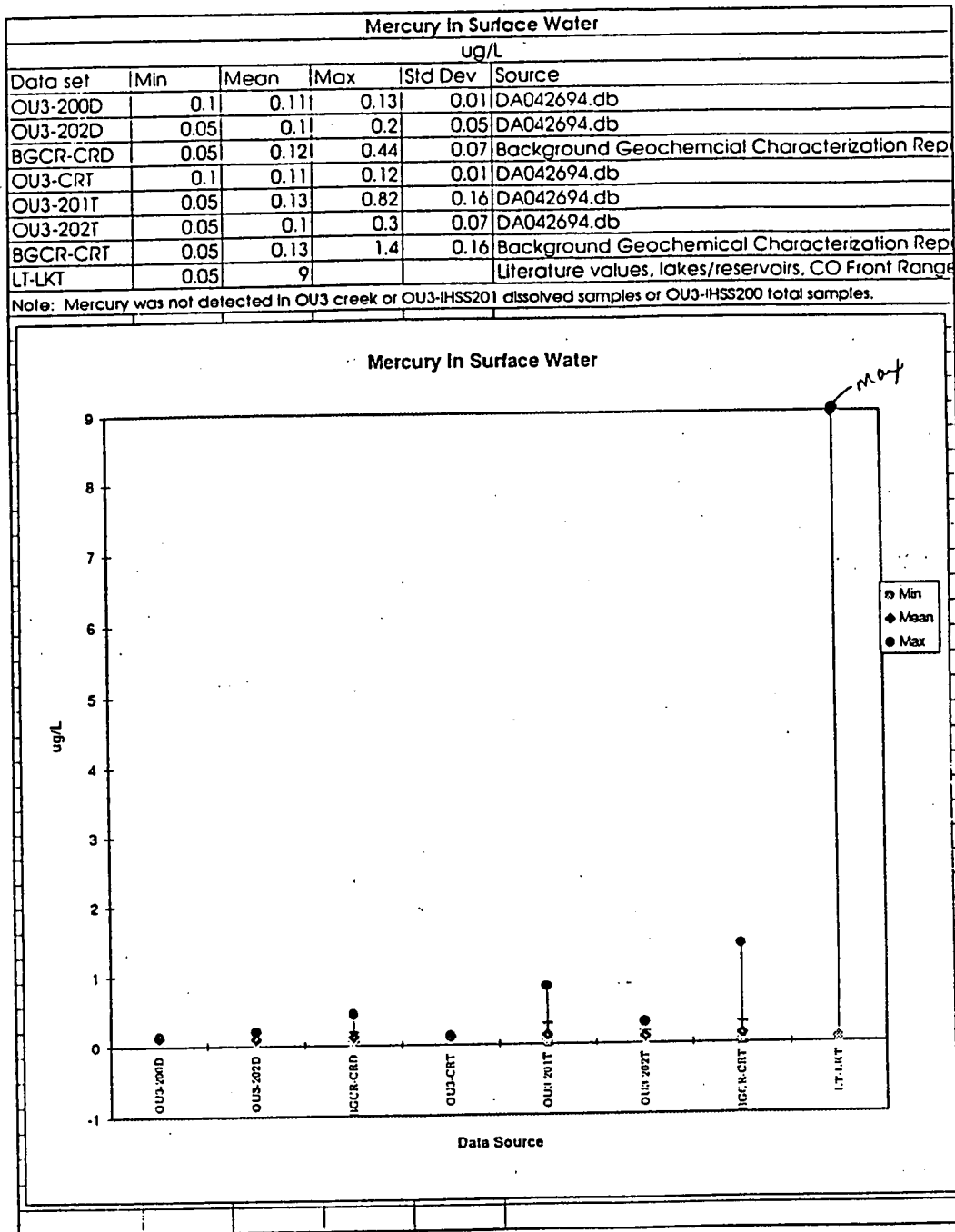
Figure 5-14. Piper diagram showing major-ion chemistry of stream water from Rock Creek. Concentrations of major ions (as meq/L) are given as percentages of the total milliequivalents per liter.

SWPLOTS Chart 6

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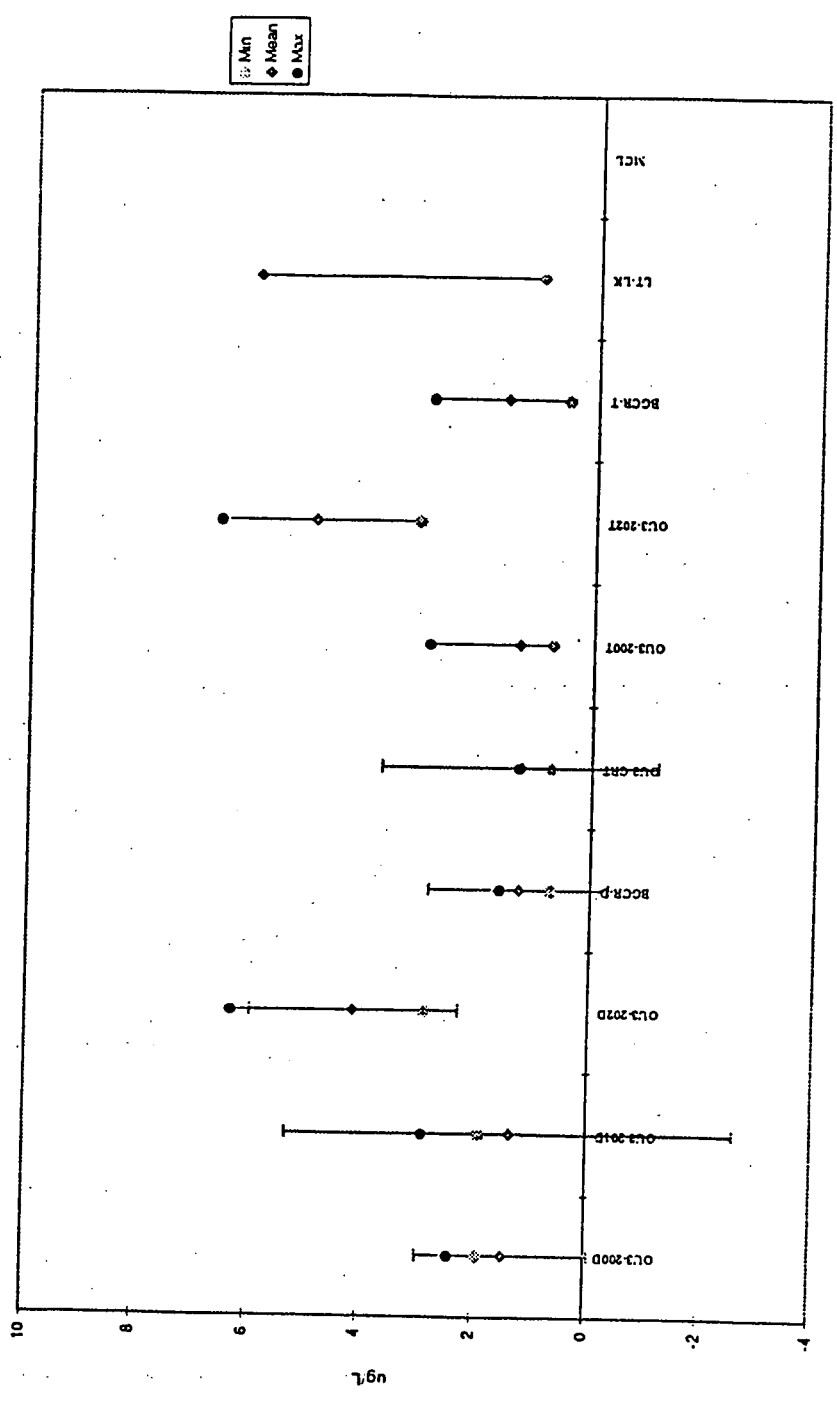
Mercury in Surface Water



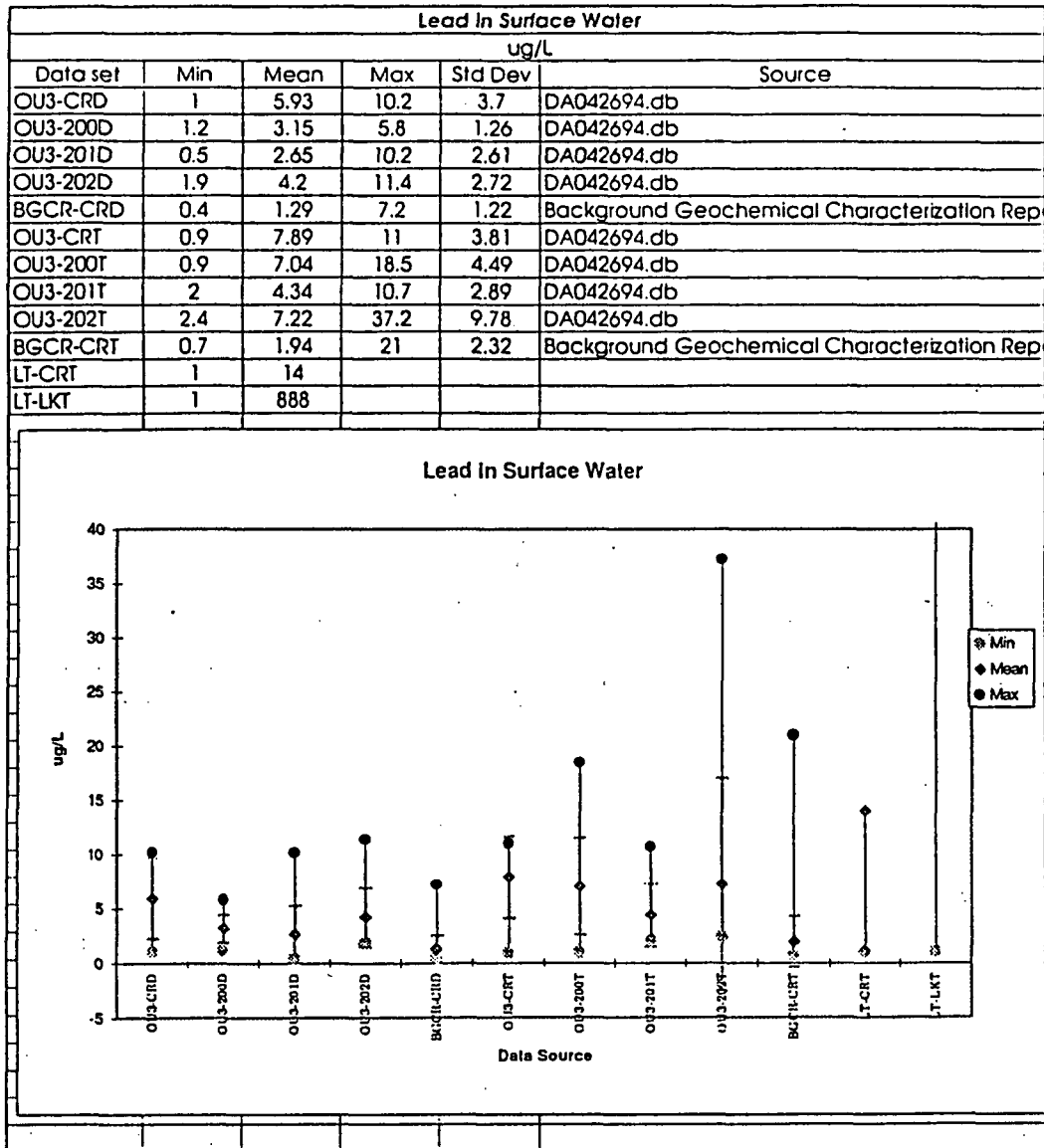


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SWPLOTS Chart 3

Arsenic in Surface Water



Date Source



SURFACE WATER PCOCS

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MAIN TEST GROUP CODE	CHEMICAL NAME	NEW UNIT	IHSS	AREA	NUMBER OF DETECTS	NUMBER OF SAMPLES	FREQUENCY OF DETECTION	MINIMUM NONDETECTED VALUE	MAXIMUM NONDETECTED VALUE	MINIMUM DETECTED VALUE	MAXIMUM DETECTED VALUE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
RADIONUCLIDES														
DISSOLVED-RADS	AMERICIUM-241	PC/L		B	34	34	1.00			-0.01	0.50	0.07	0.13	1.83
DISSOLVED-RADS	AMERICIUM-241	PC/L	CREEK	S	3	3	1.00			0.00	0.00	0.00	0.00	3.77
DISSOLVED-RADS	AMERICIUM-241	PC/L	200	S	14	14	1.00			0.00	0.02	0.00	0.01	1.56
DISSOLVED-RADS	AMERICIUM-241	PC/L	201	S	14	14	1.00			0.00	0.01	0.00	0.00	1.39
DISSOLVED-RADS	AMERICIUM-241	PC/L	202	S	12	12	1.00			-0.02	0.12	0.01	0.03	2.63
TOTAL-RADS	AMERICIUM-241	PC/L		B	106	106	1.00			-0.02	0.04	0.00	0.01	1.93
TOTAL-RADS	AMERICIUM-241	PC/L	CREEK	S	5	5	1.00			0.00	0.01	0.00	0.00	0.78
TOTAL-RADS	AMERICIUM-241	PC/L	200	S	16	16	1.00			-0.01	0.02	0.01	0.01	1.00
TOTAL-RADS	AMERICIUM-241	PC/L	201	S	17	17	1.00			0.00	0.03	0.01	0.01	1.04
TOTAL-RADS	AMERICIUM-241	PC/L	202	S	12	12	1.00			0.00	0.02	0.01	0.01	0.86
DISSOLVED-RADS	CESIUM-134	PC/L		B	3	3	1.00			2.17	2.37	2.27	0.10	0.04
TOTAL-RADS	CESIUM-134	PC/L		B	8	8	1.00			1.03	4.73	1.53	1.29	0.84
DISSOLVED-RADS	CESIUM-137	PC/L		B	10	10	1.00			-0.44	2.40	0.82	1.22	1.47
TOTAL-RADS	CESIUM-137	PC/L		B	93	93	1.00			-0.56	4.20	0.23	0.60	2.62
DISSOLVED-RADS	GROSS ALPHA	PC/L		B	60	60	1.00			-1.38	5.00	0.69	1.12	1.63
DISSOLVED-RADS	GROSS ALPHA	PC/L	200	S	16	16	1.00			-0.42	2.70	0.48	0.72	1.48
DISSOLVED-RADS	GROSS ALPHA	PC/L	201	S	15	15	1.00			-0.58	1.40	0.78	0.47	0.60
DISSOLVED-RADS	GROSS ALPHA	PC/L	202	S	12	12	1.00			-0.13	1.90	0.50	0.54	1.10
TOTAL-RADS	GROSS ALPHA	PC/L		B	85	85	1.00			-2.00	13.00	1.51	2.24	1.48
TOTAL-RADS	GROSS ALPHA	PC/L	200	S	15	15	1.00			0.07	2.20	1.12	0.73	0.65
TOTAL-RADS	GROSS ALPHA	PC/L	201	S	15	15	1.00			0.44	1.90	1.18	0.49	0.41
TOTAL-RADS	GROSS ALPHA	PC/L	202	S	11	11	1.00			-0.25	1.20	0.52	0.45	0.86
DISSOLVED-RADS	GROSS BETA	PC/L		B	61	61	1.00			-0.68	41.82	4.69	6.78	1.45
DISSOLVED-RADS	GROSS BETA	PC/L	200	S	16	16	1.00			0.08	2.90	1.62	0.83	0.51
DISSOLVED-RADS	GROSS BETA	PC/L	201	S	15	15	1.00			-0.14	4.30	1.96	1.02	0.52
DISSOLVED-RADS	GROSS BETA	PC/L	202	S	12	12	1.00			-0.25	2.10	0.76	0.73	0.96
TOTAL-RADS	GROSS BETA	PC/L		B	82	82	1.00			-0.40	36.00	4.55	5.52	1.21
TOTAL-RADS	GROSS BETA	PC/L	200	S	18	18	1.00			0.27	4.70	2.78	1.30	0.47
TOTAL-RADS	GROSS BETA	PC/L	201	S	20	20	1.00			-0.01	4.30	2.18	1.11	0.51
TOTAL-RADS	GROSS BETA	PC/L	202	S	13	13	1.00			-2.10	3.00	0.82	1.42	1.73

B = Background LT-CR = Literature Values, streams
 S = OU 3 (onsite) LT-CK = Literature Values, lakes/reservoirs

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SURFACE WATER POCs

MAIN TEST GROUP	CHEMICAL NAME	NEW UNIT	IHSS	AREA	NUMBER OF DETECTS	NUMBER OF SAMPLES	FREQUENCY OF DETECTION	MINIMUM NONDETECTED VALUE	MAXIMUM NONDETECTED VALUE	MINIMUM DETECTED VALUE	MAXIMUM DETECTED VALUE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
DISSOLVED-RADS	GROSS GAMMA	PC/L	B		24	24	1.00	-0.12	1.00	0.70	0.25	0.36		
DISSOLVED-RADS	PLUTONIUM-236	PC/L	B		4	4	1.00	-0.01	0.00	0.00	0.01	1.21		
TOTAL-RADS	PLUTONIUM-236	PC/L	B		12	12	1.00	-0.01	0.01	0.01	0.01	-1.92		
DISSOLVED-RADS	PLUTONIUM-238	PC/L	B		4	4	1.00	-0.02	0.01	0.01	0.01	1.06		
TOTAL-RADS	PLUTONIUM-238	PC/L	B		12	12	1.00	-0.02	0.01	0.01	0.01	-2.80		
DISSOLVED-RADS	PLUTONIUM-239/240	PC/L	B		36	36	1.00	-0.12	0.90	0.90	0.12	1.76		
DISSOLVED-RADS	PLUTONIUM-239/240	PC/L	CREEK	S	2	2	1.00	0.00	0.01	0.01	0.00	0.28		
DISSOLVED-RADS	PLUTONIUM-239/240	PC/L	S		9	9	1.00	0.00	0.00	0.00	0.00	-7.82		
DISSOLVED-RADS	PLUTONIUM-239/240	PC/L	S		13	13	1.00	0.00	0.01	0.01	0.00	1.30		
DISSOLVED-RADS	PLUTONIUM-239/240	PC/L	S		10	10	1.00	0.00	0.00	0.00	0.00	1.91		
TOTAL-RADS	PLUTONIUM-239/240	PC/L	B		105	105	1.00	-0.02	0.05	0.00	0.01	1.96		
TOTAL-RADS	PLUTONIUM-239/240	PC/L	CREEK	S	7	7	1.00	0.00	0.00	0.00	0.00	2.65		
TOTAL-RADS	PLUTONIUM-239/240	PC/L	S		13	13	1.00	0.00	0.01	0.01	0.00	0.80		
TOTAL-RADS	PLUTONIUM-239/240	PC/L	S		19	19	1.00	0.00	0.01	0.01	0.00	1.08		
TOTAL-RADS	PLUTONIUM-239/240	PC/L	S		12	12	1.00	-0.01	0.03	0.03	0.01	1.84		
DISSOLVED-RADS	RADU-226	PC/L	B		3	3	1.00	-0.05	0.34	0.19	0.21	1.11		
TOTAL-RADS	RADU-226	PC/L	B		4	4	1.00	-0.10	2.30	1.08	1.25	1.16		
DISSOLVED-RADS	RADU-228	PC/L	B		2	2	1.00	0.70	1.40	1.05	0.49	0.47		
DISSOLVED-RADS	STRONTIUM-89/90	PC/L	B		83	83	1.00	-0.50	3.00	0.72	0.56	0.78		
TOTAL-RADS	STRONTIUM-89/90	PC/L	B		75	75	1.00	-0.20	6.95	0.92	1.30	1.42		
DISSOLVED-RADS	TRITIUM	PC/L	B		54	54	1.00	-41.80	686.10	111.86	119.12	1.06		
TOTAL-RADS	TRITIUM	PC/L	B		73	73	1.00	-800.00	751.00	75.71	209.22	2.76		
TOTAL-RADS	TRITIUM	PC/L	S		5	5	1.00	-29.10	144.30	47.78	83.23	1.74		
DISSOLVED-RADS	URANIUM TOTAL	PC/L	B		17	17	1.00	0.10	2.20	0.59	0.52	0.88		
TOTAL-RADS	URANIUM TOTAL	PC/L	B		55	55	1.00	-0.02	1.80	0.56	0.36	1.01		
DISSOLVED-RADS	URANIUM-233/234	PC/L	S		2	2	1.00	0.48	0.48	0.48				
DISSOLVED-RADS	URANIUM-233/234	PC/L	S		12	12	1.00	0.14	0.56	0.42	0.12	0.30		
DISSOLVED-RADS	URANIUM-233/234	PC/L	S		10	10	1.00	0.17	0.70	0.51	0.18	0.52		
TOTAL-RADS	URANIUM-233/234	PC/L	B		79	79	1.00	-0.01	3.21	0.49	0.55	1.13		
TOTAL-RADS	CREEK	PC/L	S		6	6	1.00	0.78	1.27	0.69	0.53	0.77		
TOTAL-RADS	URANIUM-233/234	PC/L	S		12	12	1.00	0.19	1.20	0.61	0.31	0.51		
TOTAL-RADS	URANIUM-233/234	PC/L	S		20	20	1.00	0.08	1.30	0.75	0.35	0.47		

B = Background
 S = OU 3 (on-site)
 LT-CR = Literature Value, lake/reservoir

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SURFACE WATER PCOCS

MAIN TEST GROUP	CHEMICAL NAME	NEW UNIT	IRSS	AREA	NUMBER OF DETECTS	NUMBER OF SAMPLES	FREQUENCY OF DETECTION	MINIMUM VALUE	MAXIMUM NONDETECTED VALUE	MINIMUM DETECTED VALUE	MAXIMUM DETECTED VALUE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
TOTAL-RADS	URANIUM-235+236+238	PC/L	202	S	13	13	1.00	0.08	0.82	0.59	0.24	0.61		
DISSOLVED-RADS	URANIUM-235	PC/L	B	56	56	1.00	-0.02	0.90	0.14	0.20	1.45			
DISSOLVED-RADS	URANIUM-235	PC/L	CREEK	S	2	2	1.00	0.00	0.31	0.16	0.22	1.41		
DISSOLVED-RADS	URANIUM-235	PC/L	200	S	12	12	1.00	-0.08	0.51	0.07	0.17	2.33		
DISSOLVED-RADS	URANIUM-235	PC/L	201	S	12	12	1.00	0.00	0.71	0.15	0.26	1.76		
DISSOLVED-RADS	URANIUM-235	PC/L	202	S	10	10	1.00	-0.20	0.14	0.02	0.09	4.73		
TOTAL-RADS	URANIUM-235	PC/L	B	75	75	1.00	-0.03	0.58	0.05	0.07	1.52			
TOTAL-RADS	URANIUM-235	PC/L	CREEK	S	6	6	1.00	0.00	0.17	0.08	0.07	0.92		
TOTAL-RADS	URANIUM-235	PC/L	200	S	12	12	1.00	-0.04	0.41	0.27	0.07	1.53		
TOTAL-RADS	URANIUM-235	PC/L	201	S	20	20	1.00	-0.02	0.27	0.07	0.06	1.06		
TOTAL-RADS	URANIUM-235	PC/L	202	S	13	13	1.00	-0.03	0.15	0.03	0.06	1.83		
DISSOLVED-RADS	URANIUM-238	PC/L	B	55	55	1.00	0.00	1.70	0.28	0.27	0.98			
DISSOLVED-RADS	URANIUM-238	PC/L	CREEK	S	2	2	1.00	0.38	0.41	0.40	0.05			
DISSOLVED-RADS	URANIUM-238	PC/L	200	S	12	12	1.00	-0.05	0.58	0.30	0.19	0.63		
DISSOLVED-RADS	URANIUM-238	PC/L	201	S	12	12	1.00	-0.04	0.73	0.41	0.24	0.58		
DISSOLVED-RADS	URANIUM-238	PC/L	202	S	10	10	1.00	-0.26	0.42	0.14	0.19	1.43		
TOTAL-RADS	URANIUM-238	PC/L	B	55	55	1.00	0.00	1.82	0.36	0.43	1.18			
TOTAL-RADS	URANIUM-238	PC/L	CREEK	S	6	6	1.00	-0.02	0.87	0.52	0.33	0.44		
TOTAL-RADS	URANIUM-238	PC/L	200	S	12	12	1.00	-0.02	0.87	0.43	0.23	0.52		
TOTAL-RADS	URANIUM-238	PC/L	201	S	20	20	1.00	-0.02	1.10	0.63	0.29	0.47		
TOTAL-RADS	URANIUM-238	PC/L	202	S	12	12	1.00	0.09	0.65	0.29	0.17	0.59		
METALS														
DMETAL-CLP-NONCLP	ALUMINUM	UG/L	B	56	133	0.42	454	13.30	1050.00	87.33	160.32	1.84		
DMETAL-CLP-NONCLP	ALUMINUM	UG/L	CREEK	S	2	3	0.67	17.3	17.3	400.88	368.17	0.92		
DMETAL-CLP-NONCLP	ALUMINUM	UG/L	200	S	12	16	0.75	14.7	15.30	3230.00	448.56	2.09		
DMETAL-CLP-NONCLP	ALUMINUM	UG/L	201	S	12	17	0.71	14.7	16.40	455.00	70.16	2.01		
DMETAL-CLP-NONCLP	ALUMINUM	UG/L	202	S	5	13	0.38	14.7	17.50	47.80	16.35	0.89		
DMETAL-CLP-NONCLP	ALUMINUM	UG/L	B	106	139	0.76	988	25.00	6560.00	758.89	1360.09	1.79		
METAL-CLP-NONCLP	ALUMINUM	UG/L	CREEK	S	8	8	1.00	344.00	1990.00	1042.88	668.61	0.64		
METAL-CLP-NONCLP	ALUMINUM	UG/L	200	S	19	19	1.00	32.20	4260.00	1402.48	1035.07	0.74		
METAL-CLP-NONCLP	ALUMINUM	UG/L	201	S	20	20	1.00	65.20	1540.00	404.47	356.02	0.88		

S = 003 (onsite) LT-CK = Literature Values, lakes/reservoirs
B = Background LT-CK = Literature Values, streams

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SURFACE WATER PCOCS

DRAFT

MAIN TEST GROUP CODE	CHEMICAL NAME	NEW UNIT	IHSS	AREA	NUMBER OF DETECTS	NUMBER OF SAMPLES	FREQUENCY OF DETECTION	MINIMUM NONDETECTED VALUE	MAXIMUM NONDETECTED VALUE	MINIMUM DETECTED VALUE	MAXIMUM DETECTED VALUE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
METAL-CLP-NONCLP	ALUMINUM	UG/L	202	S	13	13	1.00			25.90	196.00	92.53	33.66	0.60
DMETAL-CLP-NONCLP	ANTIMONY	UG/L		B	20	91	0.22	7.5	104	7.50	35.10	15.91	10.14	0.64
DMETAL-CLP-NONCLP	ANTIMONY	UG/L	CREEK	S	0	2	0.00	16.3	16.3			8.25		
DMETAL-CLP-NONCLP	ANTIMONY	UG/L	200	S		16		14.8	16.3			7.77	0.44	0.06
DMETAL-CLP-NONCLP	ANTIMONY	UG/L	201	S		17		14.8	16.3			7.80	0.44	0.06
DMETAL-CLP-NONCLP	ANTIMONY	UG/L	202	S		13		14.8	16.3			7.73	0.43	0.06
METAL-CLP-NONCLP	ANTIMONY	UG/L	LT-LK	B		43		6			86.00			
METAL-CLP-NONCLP	ANTIMONY	UG/L		B	13	119	0.11	7	60	7.30	54.80	14.28	9.72	0.68
METAL-CLP-NONCLP	ANTIMONY	UG/L	CREEK	S	0	8	0.00	14.8	19.8			8.66	1.09	0.13
METAL-CLP-NONCLP	ANTIMONY	UG/L	200	S		19		14.8	19.8			8.11	0.89	0.11
METAL-CLP-NONCLP	ANTIMONY	UG/L	201	S		20		14.8	16.3			7.78	0.43	0.06
METAL-CLP-NONCLP	ANTIMONY	UG/L	202	S		13		14.8	16.3			7.73	0.43	0.06
DMETAL-CLP-NONCLP	ARSENIC	UG/L		B	4	93	0.04	0.7	10	0.90	1.60	1.27	1.26	1.00
DMETAL-CLP-NONCLP	ARSENIC	UG/L	CREEK	S	0	3	0.00	2.6	2.6			1.30		
DMETAL-CLP-NONCLP	ARSENIC	UG/L	200	S	3	16	0.19	1.9	2.9	2.40	2.40	1.46	0.51	0.35
DMETAL-CLP-NONCLP	ARSENIC	UG/L	201	S	1	18	0.06	1.9	3.2	2.90	2.90	1.36	0.46	0.34
DMETAL-CLP-NONCLP	ARSENIC	UG/L	202	S	13	13	1.00			2.90	6.30	4.14	0.99	0.24
DMETAL-CLP-NONCLP	ARSENIC	UG/L	LT-CR	B		34		5						
DMETAL-CLP-NONCLP	ARSENIC	UG/L	LT-LK	B		74		1			6.00			
METAL-CLP-NONCLP	ARSENIC	UG/L		B	15	110	0.14	0.5	11.5	1.00	2.90	1.59	1.55	0.98
METAL-CLP-NONCLP	ARSENIC	UG/L	CREEK	S	3	8	0.38	2.6	3.2	0.70	1.30	1.25	0.31	0.25
METAL-CLP-NONCLP	ARSENIC	UG/L	200	S	6	19	0.32	1.9	2.9	0.70	2.90	1.32	0.59	0.44
METAL-CLP-NONCLP	ARSENIC	UG/L	201	S		20		2.2	3.2			1.45	0.18	0.13
METAL-CLP-NONCLP	ARSENIC	UG/L	202	S	13	13	1.00			3.10	6.60	4.92	0.94	0.19
DMETAL-CLP-NONCLP	BARIUM	UG/L		B	102	144	0.71	24.5	200	18.80	391.00	48.63	34.98	0.72
DMETAL-CLP-NONCLP	BARIUM	UG/L	CREEK	S	3	3	1.00			20.70	43.10	28.40	12.74	0.45
DMETAL-CLP-NONCLP	BARIUM	UG/L	200	S	16	16	1.00			20.70	48.90	37.01	6.39	0.17
DMETAL-CLP-NONCLP	BARIUM	UG/L	201	S	18	18	1.00			21.40	43.10	35.11	4.18	0.12
DMETAL-CLP-NONCLP	BARIUM	UG/L	202	S	13	13	1.00			20.30	31.40	24.69	3.31	0.13
METAL-CLP-NONCLP	BARIUM	UG/L		B	112	131	0.85	45.5	200	26.40	306.00	63.69	31.66	0.50
METAL-CLP-NONCLP	BARIUM	UG/L	CREEK	S	8	8	1.00			25.40	80.10	37.84	18.36	0.49
METAL-CLP-NONCLP	BARIUM	UG/L	200	S	19	19	1.00			27.00	80.10	43.09	11.49	0.27
METAL-CLP-NONCLP	BARIUM	UG/L	201	S	20	20	1.00			25.40	44.50	35.89	4.52	0.13
METAL-CLP-NONCLP	BARIUM	UG/L	202	S	13	13	1.00			20.40	34.70	25.98	3.60	0.14

B = Background CL-CK = Literature Values, streams
 S = OU 3 (onsite) LT-CK = Literature Values, lakes/reservoirs

SURFACE WATER PCOCS

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MAIN TEST GROUP CODE	CHEMICAL NAME	NEW UNIT	BISS	AREA	NUMBER OF DETECTS	NUMBER OF SAMPLES	FREQUENCY OF DETECTION	MINIMUM NONDETECTED VALUE	MAXIMUM NONDETECTED VALUE	MINIMUM DETECTED VALUE	MAXIMUM DETECTED VALUE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
DMETAL-CLP-NONCLP	BERYLLIUM	UG/L		B	8	89	0.09	0.2	8	0.65	17.00	1.08	1.88	1.74
DMETAL-CLP-NONCLP	BERYLLIUM	UG/L	CREEK	S	0	3	0.00	0.4	0.4			0.20		
DMETAL-CLP-NONCLP	BERYLLIUM	UG/L	200	S		16		0.3	0.4			0.17	0.03	0.15
DMETAL-CLP-NONCLP	BERYLLIUM	UG/L	201	S		18		0.3	0.4			0.18	0.03	0.15
DMETAL-CLP-NONCLP	BERYLLIUM	UG/L	202	S		13		0.3	0.4			0.17	0.03	0.15
METAL-CLP-NONCLP	BERYLLIUM	UG/L		B	9	115	0.08	0.2	5	0.60	4.80	0.78	0.87	1.12
METAL-CLP-NONCLP	BERYLLIUM	UG/L	CREEK	S	1	8	0.13	0.3	0.6	0.36	0.36	0.25	0.07	0.29
METAL-CLP-NONCLP	BERYLLIUM	UG/L	200	S	1	19	0.05	0.3	0.6	0.40	0.40	0.20	0.07	0.35
METAL-CLP-NONCLP	BERYLLIUM	UG/L	201	S	1	20	0.05	0.3	0.4	0.36	0.36	0.18	0.05	0.27
METAL-CLP-NONCLP	BERYLLIUM	UG/L	202	S		13		0.3	0.4			0.17	0.03	0.15
DMETAL-CLP-NONCLP	CADMIUM	UG/L		B	5	77	0.06	1.4	5	2.30	3.50	1.77	0.62	0.35
DMETAL-CLP-NONCLP	CADMIUM	UG/L	CREEK	S	1	3	0.33	1.4	1.4	2.50	2.50	1.30	1.04	0.80
DMETAL-CLP-NONCLP	CADMIUM	UG/L	200	S	1	16	0.06	1.4	1.5	1.50	1.50	0.78	0.19	0.25
DMETAL-CLP-NONCLP	CADMIUM	UG/L	201	S	2	18	0.11	1.4	1.5	2.50	2.50	0.93	0.57	0.62
DMETAL-CLP-NONCLP	CADMIUM	UG/L	202	S	1	13	0.08	1.4	1.5	1.80	1.80	0.82	0.30	0.36
METAL-CLP-NONCLP	CADMIUM	UG/L	LT-CR	B		33		1			2.50			
METAL-CLP-NONCLP	CADMIUM	UG/L	LT-LK	B		164		0.1			17.00			
METAL-CLP-NONCLP	CADMIUM	UG/L		B	3	108	0.03	1.4	5	2.60	4.20	1.69	0.68	0.40
METAL-CLP-NONCLP	CADMIUM	UG/L	CREEK	S	3	8	0.38	1.4	2.3	2.40	2.80	1.47	0.93	0.63
METAL-CLP-NONCLP	CADMIUM	UG/L	200	S	3	19	0.16	1.4	2.3	1.90	2.80	1.02	0.64	0.63
METAL-CLP-NONCLP	CADMIUM	UG/L	201	S	1	20	0.05	1.4	1.5	2.40	2.40	0.81	0.37	0.46
METAL-CLP-NONCLP	CADMIUM	UG/L	202	S	2	13	0.15	1.4	1.5	4.00	9.00	1.62	2.39	1.48
DMETAL-CLP-NONCLP	CALCIUM	UG/L		B	153	153	1.00			6760.00	79300.00	24056.86	10904.89	0.45
DMETAL-CLP-NONCLP	CALCIUM	UG/L	CREEK	S	3	3	1.00			13900.00	27200.00	18566.67	7484.87	0.40
DMETAL-CLP-NONCLP	CALCIUM	UG/L	200	S	16	16	1.00			13900.00	22000.00	19156.25	1822.44	0.10
DMETAL-CLP-NONCLP	CALCIUM	UG/L	201	S	18	18	1.00			14600.00	27200.00	23127.78	2520.46	0.11
DMETAL-CLP-NONCLP	CALCIUM	UG/L	202	S	13	13	1.00			11200.00	14200.00	12792.31	1028.32	0.08
METAL-CLP-NONCLP	CALCIUM	UG/L		B	153	153	1.00			5505.75	74600.00	24071.96	10675.23	0.44
METAL-CLP-NONCLP	CALCIUM	UG/L	CREEK	S	8	8	1.00			11000.00	47200.00	21212.50	12141.48	0.57
METAL-CLP-NONCLP	CALCIUM	UG/L	200	S	19	19	1.00			11000.00	47200.00	19621.05	7339.13	0.37
METAL-CLP-NONCLP	CALCIUM	UG/L	201	S	20	20	1.00			12600.00	26100.00	22085.00	3340.39	0.15
METAL-CLP-NONCLP	CALCIUM	UG/L	202	S	13	13	1.00			11100.00	13900.00	12676.92	840.79	0.07
DMETAL-CLP-NONCLP	CESIUM	UG/L		B	9	97	0.09	2	2500	60.00	200.00	355.86	281.41	0.79
DMETAL-CLP-NONCLP	CESIUM	UG/L	CREEK	S	0	3	0.00	50	50			25.00		

B = Background LT-CR = Literature Values, streams
 S = OU 3 (onsite) LT-LK = Literature Values, lakes/reservoirs

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SURFACE WATER PCOCS

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MAIN TEST GROUP CODE	CHEMICAL NAME	NEW UNIT	IHSS	AREA	NUMBER OF DETECTS	NUMBER OF SAMPLES	FREQUENCY OF DETECTION	MINIMUM NONDETECTED VALUE	MAXIMUM NONDETECTED VALUE	MINIMUM DETECTED VALUE	MAXIMUM DETECTED VALUE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
DMETAL-CLP-NONCLP	CESIUM	UG/L	200	S	4	16	0.25	50	50	50.00	60.00	31.88	12.50	0.39
DMETAL-CLP-NONCLP	CESIUM	UG/L	201	S	5	18	0.28	50	50	50.00	80.00	34.72	17.19	0.50
DMETAL-CLP-NONCLP	CESIUM	UG/L	202	S	4	13	0.31	50	50	50.00	80.00	36.54	19.31	0.53
METAL-CLP-NONCLP	CESIUM	UG/L		B	10	120	0.08	2	2500	50.00	400.00	241.78	184.80	0.76
METAL-CLP-NONCLP	CESIUM	UG/L	CREEK	S	0	8	0.00	50	500		109.38	116.43		1.06
METAL-CLP-NONCLP	CESIUM	UG/L	200	S	5	19	0.26	50	500	50.00	90.00	69.21	82.15	1.19
METAL-CLP-NONCLP	CESIUM	UG/L	201	S		20		50	50		25.00			
METAL-CLP-NONCLP	CESIUM	UG/L	202	S	3	13	0.23	50	50	50.00	80.00	33.85	17.93	0.53
DMETAL-CLP-NONCLP	CHROMIUM	UG/L		B	9	89	0.10	2	20	2.10	14.80	3.24	2.69	0.83
DMETAL-CLP-NONCLP	CHROMIUM	UG/L	CREEK	S	0	3	0.00	3.7	3.7			1.85		
DMETAL-CLP-NONCLP	CHROMIUM	UG/L	200	S		16		2.6	3.7			1.54	0.28	0.18
DMETAL-CLP-NONCLP	CHROMIUM	UG/L	201	S	1	18	0.06	2.6	3.7	3.80	3.80	1.71	0.59	0.34
DMETAL-CLP-NONCLP	CHROMIUM	UG/L	202	S	1	13	0.08	2.6	3.7	3.40	3.40	1.67	0.59	0.35
METAL-CLP-NONCLP	CHROMIUM	UG/L	LT-CR	B		32		5			5.00			
METAL-CLP-NONCLP	CHROMIUM	UG/L	LT-LK	B		165				1.00	11.00			
METAL-CLP-NONCLP	CHROMIUM	UG/L		B	19	120	0.16	2	13.5	2.10	18.90	3.64	2.98	0.82
METAL-CLP-NONCLP	CHROMIUM	UG/L	CREEK	S	1	8	0.13	2	3.7	2.90	2.90	1.59	0.66	0.41
METAL-CLP-NONCLP	CHROMIUM	UG/L	200	S	2	19	0.11	2	3.7	4.30	4.40	1.72	0.97	0.57
METAL-CLP-NONCLP	CHROMIUM	UG/L	201	S	2	20	0.10	2.6	3.7	2.80	2.90	1.70	0.48	0.28
METAL-CLP-NONCLP	CHROMIUM	UG/L	202	S	1	13	0.08	2.6	3.7	65.80	65.80	6.47	17.83	2.75
DMETAL-CLP-NONCLP	COBALT	UG/L		B	3	86	0.03	2	50	2.40	4.60	4.88	6.26	1.28
DMETAL-CLP-NONCLP	COBALT	UG/L	CREEK	S	0	3	0.00	2.3	2.3			1.15		
DMETAL-CLP-NONCLP	COBALT	UG/L	200	S	1	16	0.06	1.3	2.3	1.90	1.90	0.93	0.36	0.38
DMETAL-CLP-NONCLP	COBALT	UG/L	201	S		18		1.3	2.3			0.90	0.26	0.29
DMETAL-CLP-NONCLP	COBALT	UG/L	202	S	1	13	0.08	1.3	2.3	1.80	1.80	0.93	0.36	0.39
METAL-CLP-NONCLP	COBALT	UG/L		B	8	116	0.07	2	50	2.70	7.90	5.35	8.07	1.51
METAL-CLP-NONCLP	COBALT	UG/L	CREEK	S	0	8	0.00	1.3	2.7			1.10	0.29	0.27
METAL-CLP-NONCLP	COBALT	UG/L	200	S	3	19	0.16	1.3	2.7	1.50	2.60	1.14	0.47	0.42
METAL-CLP-NONCLP	COBALT	UG/L	201	S	2	20	0.10	1.3	2.3	1.30	1.90	0.97	0.34	0.35
METAL-CLP-NONCLP	COBALT	UG/L	202	S		13		1.3	2.3			0.84	0.25	0.30
DMETAL-CLP-NONCLP	COPPER	UG/L		B	48	124	0.39	2	25.7	2.40	28.00	6.07	5.12	0.84
DMETAL-CLP-NONCLP	COPPER	UG/L	CREEK	S	2	3	0.67	2.4	2.4	5.50	8.10	4.93	3.48	0.71
DMETAL-CLP-NONCLP	COPPER	UG/L	200	S	9	16	0.56	1.9	2.4	2.00	9.40	3.15	2.67	0.85
DMETAL-CLP-NONCLP	COPPER	UG/L	201	S	6	18	0.33	1.9	2.4	1.90	8.10	1.77	1.66	0.94

B = Background LT-CR = Literature Values, creeks
 S = OU 3 (onsite) LT-LK = Literature Values, lakes/reservoirs

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SURFACE WATER PCOCS

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MAIN TEST GROUP CODE	CHEMICAL NAME	NEW UNIT	IHSS	AREA	NUMBER OF DETECTS	NUMBER OF SAMPLES	FREQUENCY OF DETECTION	MINIMUM NONDETECTED VALUE	MAXIMUM NONDETECTED VALUE	MINIMUM DETECTED VALUE	MAXIMUM DETECTED VALUE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
DMETAL-CLP-NONCLP	COPPER	UG/L	202	S	5	12	0.42	1.9	2.4	2.10	4.50	1.94	1.19	0.62
METAL-CLP-NONCLP	COPPER	UG/L	LT-CR	B		33		1			49.00			
METAL-CLP-NONCLP	COPPER	UG/L	LT-LK	B		174		1			27.00			
METAL-CLP-NONCLP	COPPER	UG/L		B	47	121	0.39	2	25.6	2.60	15.50	5.35	4.21	0.79
METAL-CLP-NONCLP	COPPER	UG/L	CREEK	S	7	8	0.88	2.3	2.3	5.80	20.90	13.24	7.40	0.56
METAL-CLP-NONCLP	COPPER	UG/L	200	S	13	15	0.87	1.9	2.3	4.30	20.90	9.25	6.35	0.69
METAL-CLP-NONCLP	COPPER	UG/L	201	S	16	17	0.94	1.9	1.9	2.80	16.50	5.84	4.23	0.73
METAL-CLP-NONCLP	COPPER	UG/L	202	S	3	13	0.23	1.9	2.4	2.20	4.50	1.58	1.11	0.70
DMETAL-CLP-NONCLP	CYANIDE	UG/L		B		1		10	10			5.00		
METAL-CLP-NONCLP	CYANIDE	UG/L		B	2	23	0.08	1.5	20	2.00	2.50	2.50	2.72	1.09
METAL-CLP-NONCLP	CYANIDE	UG/L	200	S		5		10	10			5.00		
METAL-CLP-NONCLP	CYANIDE	UG/L	201	S	1	5	0.20	10	10	21.50	21.50	8.30	7.38	0.89
METAL-CLP-NONCLP	CYANIDE	UG/L	202	S		4		10	10			5.00		
DMETAL-CLP-NONCLP	IRON	UG/L		B	107	152	0.70	3	316	9.30	1060.00	145.45	177.80	1.22
DMETAL-CLP-NONCLP	IRON	UG/L	CREEK	S	3	3	1.00			19.80	228.00	112.27	0.85	
DMETAL-CLP-NONCLP	IRON	UG/L	200	S	12	15	0.80	4	16.3	6.60	572.00	93.62	144.89	1.55
DMETAL-CLP-NONCLP	IRON	UG/L	201	S	12	15	0.80	16.3	16.3	11.00	228.00	36.10	54.28	1.50
DMETAL-CLP-NONCLP	IRON	UG/L	202	S	13	13	1.00			7.00	71.10	35.46	22.08	0.62
METAL-CLP-NONCLP	IRON	UG/L	LT-CR	B		34		10			3300.00			
METAL-CLP-NONCLP	IRON	UG/L	LT-LK	B		177		10			1600.00			
METAL-CLP-NONCLP	IRON	UG/L		B	147	157	0.94	82.75	478	9.70	26300.00	1261.17	2865.13	2.27
METAL-CLP-NONCLP	IRON	UG/L	CREEK	S	8	8	1.00			453.00	2340.00	1218.88	719.98	0.59
METAL-CLP-NONCLP	IRON	UG/L	200	S	19	19	1.00			40.70	2340.00	1115.04	685.21	0.61
METAL-CLP-NONCLP	IRON	UG/L	201	S	20	20	1.00			37.70	1150.00	401.56	332.31	0.83
METAL-CLP-NONCLP	IRON	UG/L	202	S	13	13	1.00			56.50	328.00	156.69	75.05	0.48
DMETAL-CLP-NONCLP	LEAD	UG/L		B	25	112	0.22	0.4	13.1	0.70	7.20	1.29	1.22	0.94
DMETAL-CLP-NONCLP	LEAD	UG/L	CREEK	S	3	3	1.00			3.60	10.20	5.93	3.70	0.62
DMETAL-CLP-NONCLP	LEAD	UG/L	200	S	16	16	1.00			1.20	5.80	3.15	1.26	0.40
DMETAL-CLP-NONCLP	LEAD	UG/L	201	S	9	18	0.50	1	2.2	2.10	10.20	2.65	2.61	0.99
DMETAL-CLP-NONCLP	LEAD	UG/L	202	S	12	13	0.92	1.9	1.9	2.10	11.40	4.20	2.72	0.65
METAL-CLP-NONCLP	LEAD	UG/L	LT-CR	B		33		1			14.00			
METAL-CLP-NONCLP	LEAD	UG/L	LT-LK	B		148				1.00	888.00			
METAL-CLP-NONCLP	LEAD	UG/L		B	52	131	0.40	0.7	11.6	0.80	21.00	1.94	2.32	1.20
METAL-CLP-NONCLP	LEAD	UG/L	CREEK	S	8	8	1.00			0.90	11.00	7.99	3.81	0.48

B = Background LT-CR = Literature Values, streams
 S = OU 3 (onsite) LT-LK = Literature Values, lakes/reservoirs

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SURFACE WATER PCOCS

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MAIN TEST GROUP CODE	CHEMICAL NAME	NEW UNIT	IHSS	AREA	NUMBER OF DETECTS	NUMBER OF SAMPLES	FREQUENCY OF DETECTION	MINIMUM NONDETECTED VALUE	MAXIMUM NONDETECTED VALUE	MINIMUM DETECTED VALUE	MAXIMUM DETECTED VALUE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
METAL-CLP-NONCLP	LEAD	UG/L	200	S	19	19	1.00			0.90	18.30	7.04	4.49	0.64
METAL-CLP-NONCLP	LEAD	UG/L	201	S	17	20	0.85	2	2.7	2.50	10.70	4.34	2.89	0.67
METAL-CLP-NONCLP	LEAD	UG/L	202	S	13	13	1.00			2.40	37.20	7.22	9.78	1.35
DMETAL-CLP-NONCLP	LITHIUM	UG/L		B	51	118	0.43	1	101	1.30	12.80	15.97	20.53	1.29
DMETAL-CLP-NONCLP	LITHIUM	UG/L	CREEK	S	3	3	1.00			5.80	12.00	7.90	3.55	0.45
DMETAL-CLP-NONCLP	LITHIUM	UG/L	200	S	15	16	0.94	3.7	3.7	3.80	8.20	5.58	1.52	0.27
DMETAL-CLP-NONCLP	LITHIUM	UG/L	201	S	18	18	1.00			5.90	12.00	7.65	1.41	0.18
DMETAL-CLP-NONCLP	LITHIUM	UG/L	202	S	13	13	1.00			6.30	10.60	8.22	1.34	0.16
METAL-CLP-NONCLP	LITHIUM	UG/L		B	59	126	0.47	2	100	2.00	15.50	11.76	17.38	1.48
METAL-CLP-NONCLP	LITHIUM	UG/L	CREEK	S	7	7	1.00			3.50	11.10	7.40	2.54	0.34
METAL-CLP-NONCLP	LITHIUM	UG/L	200	S	18	18	1.00			3.50	8.70	6.34	1.45	0.23
METAL-CLP-NONCLP	LITHIUM	UG/L	201	S	20	20	1.00			4.90	11.10	7.72	1.63	0.21
METAL-CLP-NONCLP	LITHIUM	UG/L	202	S	13	13	1.00			5.20	9.40	7.29	1.35	0.19
DMETAL-CLP-NONCLP	MAGNESIUM	UG/L		B	133	149	0.89	3300	5000	1890.00	17800.00	5004.04	1987.74	0.40
DMETAL-CLP-NONCLP	MAGNESIUM	UG/L	CREEK	S	3	3	1.00			3080.00	6310.00	4303.33	1751.69	0.41
DMETAL-CLP-NONCLP	MAGNESIUM	UG/L	200	S	16	16	1.00			3080.00	4320.00	3941.88	273.31	0.07
DMETAL-CLP-NONCLP	MAGNESIUM	UG/L	201	S	18	18	1.00			3520.00	6310.00	5331.11	546.30	0.10
DMETAL-CLP-NONCLP	MAGNESIUM	UG/L	202	S	13	13	1.00			5930.00	7160.00	6627.69	452.59	0.07
METAL-CLP-NONCLP	MAGNESIUM	UG/L		B	134	146	0.92	4100	5000	1870.00	16600.00	5125.31	1924.26	0.38
METAL-CLP-NONCLP	MAGNESIUM	UG/L	CREEK	S	8	8	1.00			2940.00	11100.00	5297.50	2771.48	0.52
METAL-CLP-NONCLP	MAGNESIUM	UG/L	200	S	19	19	1.00			2940.00	11100.00	4328.42	1689.44	0.39
METAL-CLP-NONCLP	MAGNESIUM	UG/L	201	S	20	20	1.00			3450.00	6480.00	5338.00	596.74	0.11
METAL-CLP-NONCLP	MAGNESIUM	UG/L	202	S	13	13	1.00			5820.00	7340.00	6568.46	586.74	0.09
DMETAL-CLP-NONCLP	MANGANESE	UG/L		B	115	148	0.78	0.94	15	1.00	353.00	28.47	47.75	1.68
DMETAL-CLP-NONCLP	MANGANESE	UG/L	CREEK	S	3	3	1.00			4.80	63.10	42.00	32.31	0.77
DMETAL-CLP-NONCLP	MANGANESE	UG/L	200	S	16	16	1.00			0.90	94.20	19.01	31.29	1.64
DMETAL-CLP-NONCLP	MANGANESE	UG/L	201	S	14	18	0.78	0.9	0.9	1.60	1570.00	118.88	372.43	3.13
DMETAL-CLP-NONCLP	MANGANESE	UG/L	202	S	13	13	1.00			2.70	7.90	4.85	1.73	0.36
METAL-CLP-NONCLP	MANGANESE	UG/L	LT-CR	B		35			8	1800.00				
METAL-CLP-NONCLP	MANGANESE	UG/L	LT-LK	B		153			1	400.00				
METAL-CLP-NONCLP	MANGANESE	UG/L		B	138	151	0.91	1.3	15	1.00	4060.00	87.07	343.53	3.95
METAL-CLP-NONCLP	MANGANESE	UG/L	CREEK	S	8	8	1.00			97.00	307.00	169.00	70.21	
METAL-CLP-NONCLP	MANGANESE	UG/L	200	S	19	19	1.00			6.80	210.00	71.51	66.18	0.93
METAL-CLP-NONCLP	MANGANESE	UG/L	201	S	20	20	1.00			5.50	1580.00	155.99	357.73	2.29

B = Background LT-CR = Literature Values, streams
 S = OU 3 (onsite) LT-LK = Literature Values, lakes/reservoirs

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SURFACE WATER PCOCS

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MAIN TEST GROUP CODE	CHEMICAL NAME	NEW UNIT	IHSS	AREA	NUMBER OF DETECTS	NUMBER OF SAMPLES	FREQUENCY OF DETECTION	MINIMUM NONDETECTED VALUE	MAXIMUM NONDETECTED VALUE	MINIMUM DETECTED VALUE	MAXIMUM DETECTED VALUE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
METAL-CLP-NONCLP	MANGANESE	UG/L	202	S	13	13	1.00			11.80	37.00	21.96	8.28	0.38
DMETAL-CLP-NONCLP	MERCURY	UG/L		B	8	82	0.10	0.1	0.2	0.22	0.44	0.12	0.07	0.59
DMETAL-CLP-NONCLP	MERCURY	UG/L	CREEK	S										
DMETAL-CLP-NONCLP	MERCURY	UG/L	200	S	5	16	0.31	0.2	0.2	0.13	0.13	0.11	0.01	0.13
DMETAL-CLP-NONCLP	MERCURY	UG/L	201	S		18		0.1	0.2			0.09	0.02	0.27
DMETAL-CLP-NONCLP	MERCURY	UG/L	202	S	2	13	0.15	0.1	0.2	0.20	0.20	0.10	0.05	0.54
METAL-CLP-NONCLP	MERCURY	UG/L	LT-CR	B		35		5			0.20			
METAL-CLP-NONCLP	MERCURY	UG/L	LT-LK	B		124		0.1			9.00			
METAL-CLP-NONCLP	MERCURY	UG/L		B	9	122	0.07	0.1	0.42	0.20	1.40	0.13	0.16	1.21
METAL-CLP-NONCLP	MERCURY	UG/L	CREEK	S	2	8	0.25	0.2	0.2	0.12	0.12	0.11	0.01	0.09
METAL-CLP-NONCLP	MERCURY	UG/L	200	S		19		0.1	0.2			0.09	0.02	0.26
METAL-CLP-NONCLP	MERCURY	UG/L	201	S	3	20	0.15	0.1	0.2	0.12	0.82	0.13	0.16	1.28
METAL-CLP-NONCLP	MERCURY	UG/L	202	S	2	13	0.15	0.1	0.2	0.20	0.30	0.10	0.07	0.69
DMETAL-CLP-NONCLP	MOLYBDENUM	UG/L		B	14	92	0.15	2	500	2.50	23.40	33.19	49.35	1.49
DMETAL-CLP-NONCLP	MOLYBDENUM	UG/L	CREEK	S	3	3	1.00			3.40	6.60	4.77	1.65	0.35
DMETAL-CLP-NONCLP	MOLYBDENUM	UG/L	200	S	16	16	1.00			2.00	7.00	4.64	1.49	0.32
DMETAL-CLP-NONCLP	MOLYBDENUM	UG/L	201	S	18	18	1.00			2.70	8.80	5.17	1.44	0.28
DMETAL-CLP-NONCLP	MOLYBDENUM	UG/L	202	S	2	13	0.15	1.7	2.7	2.70	3.10	1.36	0.73	0.54
METAL-CLP-NONCLP	MOLYBDENUM	UG/L		B	12	125	0.10	2	100	2.10	20.30	12.13	17.41	1.44
METAL-CLP-NONCLP	MOLYBDENUM	UG/L	CREEK	S	6	8	0.75	3.5	3.5	3.50	7.40	4.53	2.07	0.46
METAL-CLP-NONCLP	MOLYBDENUM	UG/L	200	S	17	19	0.89	3.5	3.5	3.60	8.20	5.08	1.61	0.32
METAL-CLP-NONCLP	MOLYBDENUM	UG/L	201	S	20	20	1.00			3.30	7.70	5.29	1.35	0.25
METAL-CLP-NONCLP	MOLYBDENUM	UG/L	202	S	5	13	0.38	1.7	2.7	1.90	4.40	1.78	1.00	0.56
DMETAL-CLP-NONCLP	NICKEL	UG/L		B	4	85	0.05	3	40	6.20	21.80	7.47	5.58	0.75
DMETAL-CLP-NONCLP	NICKEL	UG/L	CREEK	S	0	3	0.00	6	6			3.00		
DMETAL-CLP-NONCLP	NICKEL	UG/L	200	S	1	16	0.06	2.6	6	3.50	3.50	2.18	0.92	0.42
DMETAL-CLP-NONCLP	NICKEL	UG/L	201	S	3	18	0.17	2.6	6	2.80	3.40	2.44	0.84	0.34
DMETAL-CLP-NONCLP	NICKEL	UG/L	202	S	2	13	0.15	2.6	6	2.90	6.60	2.48	1.50	0.60
METAL-CLP-NONCLP	NICKEL	UG/L	LT-CR	B		34		10			20.00			
METAL-CLP-NONCLP	NICKEL	UG/L	LT-LK	B		142		10			24.00			
METAL-CLP-NONCLP	NICKEL	UG/L		B	15	120	0.13	3	40	3.80	12.80	7.11	5.88	0.83
METAL-CLP-NONCLP	NICKEL	UG/L	CREEK	S	1	8	0.13	2.6	11.2	2.80	2.80	3.74	1.64	0.44
METAL-CLP-NONCLP	NICKEL	UG/L	200	S	6	19	0.32	2.6	11.2	2.70	6.50	3.32	1.59	0.48
METAL-CLP-NONCLP	NICKEL	UG/L	201	S	5	20	0.25	2.6	6	2.80	33.10	4.19	6.89	1.65

B = Background LT-CR = Literature Values, streams
 S = OU 3 (omite) LT-LK = Literature Values, lakes/reservoirs

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SURFACE WATER PCOCS

MAIN TEST GROUP	CHEMICAL NAME	NEW UNIT	IBSS	AREA	NUMBER OF DETECTS	NUMBER OF SAMPLES	FREQUENCY OF DETECTION	MINIMUM VALUE NONDETECTED	MAXIMUM VALUE NONDETECTED	MINIMUM VALUE DETECTED	MAXIMUM VALUE DETECTED	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
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METAL-CLP-NONCLP	NICKEL	UG/L	202	S	4	13	0.11	2.6	6	2.80	23.00	4.56	6.02	1.32
METAL-CLP-NONCLP	PHOSPHORUS	UG/L		B	4	6	0.67	80	296	102.00	398.00	163.50	122.37	0.75
METAL-CLP-NONCLP	PHOSPHORUS	UG/L		B	1	6	0.17	101	456	157.00	157.00	110.42	68.30	0.62
METAL-CLP-NONCLP	POTASSIUM	UG/L		B	86	123	0.69	390	5000	402.00	6800.00	1612.34	1011.90	0.63
METAL-CLP-NONCLP	POTASSIUM	UG/L		CREEK	3	3	1.00			1130.00	2170.00	1626.67	521.57	0.32
METAL-CLP-NONCLP	POTASSIUM	UG/L	200	S	16	16	1.00			2170.00	2030.00	1559.38	181.38	0.12
METAL-CLP-NONCLP	POTASSIUM	UG/L	201	S	18	18	1.00			1580.00	2170.00	1858.33	122.87	0.07
METAL-CLP-NONCLP	POTASSIUM	UG/L	202	S	13	13	1.00			141.00	640.00	412.77	202.77	0.49
METAL-CLP-NONCLP	POTASSIUM	UG/L		B	93	128	0.73	380	5000	493.00	6700.00	1817.03	1058.86	0.58
METAL-CLP-NONCLP	POTASSIUM	UG/L		CREEK	8	8	1.00			1260.00	6390.00	2611.25	1621.01	0.62
METAL-CLP-NONCLP	POTASSIUM	UG/L	200	S	19	19	1.00			1340.00	6390.00	2051.05	1105.88	0.54
METAL-CLP-NONCLP	POTASSIUM	UG/L	201	S	20	20	1.00			2370.00	1913.50	1913.50	233.85	0.12
METAL-CLP-NONCLP	POTASSIUM	UG/L	202	S	13	13	1.00			147.00	740.00	420.31	211.72	0.50
METAL-CLP-NONCLP	SELENIUM	UG/L		B	7	84	0.08	0.8	20	0.83	8.60	1.58	1.72	1.09
METAL-CLP-NONCLP	SELENIUM	UG/L	1	S	1	3	0.33	3.7	3.90	3.90	2.53	1.18	0.47	
METAL-CLP-NONCLP	SELENIUM	UG/L	200	S	16			2.9	3.8		1.71	0.20	0.12	
METAL-CLP-NONCLP	SELENIUM	UG/L	201	S	3	18	0.17	2.8	3.9	3.00	3.90	2.05	0.75	0.37
METAL-CLP-NONCLP	SELENIUM	UG/L	202	S	13	1	0.08	2.9	3.8	3.00	3.00	1.64	0.43	0.26
METAL-CLP-NONCLP	SELENIUM	UG/L		B	35			5			5.00			
METAL-CLP-NONCLP	SELENIUM	UG/L	LT-LK	B	124			1						
METAL-CLP-NONCLP	SELENIUM	UG/L		B	16	16	0.06	0.8	20	0.80	6.20	1.27	1.19	0.93
METAL-CLP-NONCLP	SELENIUM	UG/L		CREEK	8	0	0.00	0.8	3.9			1.33	0.77	0.58
METAL-CLP-NONCLP	SELENIUM	UG/L	200	S	19	19	0.05	0.8	3.8	3.30	2.06	0.77	0.34	
METAL-CLP-NONCLP	SELENIUM	UG/L	201	S	1	20		2.8	3.9	3.30	2.06	0.77	0.38	
METAL-CLP-NONCLP	SELENIUM	UG/L	202	S	13			2.9	3.8		1.66	0.20	0.12	
METAL-CLP-NONCLP	SELENIUM	UG/L		S	16	16	1.00			469.00	3100.00	1413.06	782.73	0.45
METAL-CLP-NONCLP	SELENIUM	UG/L		CREEK	3	3	1.00			1240.00	3390.00	2576.67	1166.63	0.43
METAL-CLP-NONCLP	SELENIUM	UG/L	201	S	18	18	1.00			865.00	3390.00	1459.33	619.80	0.42
METAL-CLP-NONCLP	SELENIUM	UG/L	202	S	13	13	1.00			410.00	3330.00	1476.69	1154.47	0.78
METAL-CLP-NONCLP	SELENIUM	UG/L		B	67	67	1.00			690.00	15300.00	6076.23	3377.17	0.56
METAL-CLP-NONCLP	SELENIUM	UG/L		CREEK	8	8	1.00			928.00	7770.00	4097.25	2484.62	0.61
METAL-CLP-NONCLP	SELENIUM	UG/L	200	S	19	19	1.00			544.00	7770.00	2469.89	2107.20	0.83
METAL-CLP-NONCLP	SELENIUM	UG/L	201	S	20	20	1.00			928.00	4040.00	1636.95	880.01	0.54
METAL-CLP-NONCLP	SELENIUM	UG/L	202	S	13	13	1.00			348.00	3250.00	1345.23	1107.18	0.82

0 = Blank/Unknown
LT-LK = Literature Values, Lakes/Reservoirs
S = Out (onsite)

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SURFACE WATER PCOCS

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MAIN TEST GROUP CODE	CHEMICAL NAME	NEW UNIT	IHSS	AREA	NUMBER OF DETECTS	NUMBER OF SAMPLES	FREQUENCY OF DETECTION	MINIMUM NONDETECTED VALUE	MAXIMUM NONDETECTED VALUE	MINIMUM DETECTED VALUE	MAXIMUM DETECTED VALUE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
DMETAL-CLP-NONCLP	SILVER	UG/L		B	9	98	0.09	2	30	2.60	9.20	2.75	2.72	0.99
DMETAL-CLP-NONCLP	SILVER	UG/L	CREEK	S	1	3	0.33	2.3	2.3	3.80	3.80	2.03	1.53	0.75
DMETAL-CLP-NONCLP	SILVER	UG/L	200	S	5	16	0.31	2.3	3.6	2.50	3.80	2.04	0.65	0.32
DMETAL-CLP-NONCLP	SILVER	UG/L	201	S		14		2.3	3.6			1.38	0.32	0.23
DMETAL-CLP-NONCLP	SILVER	UG/L	202	S		13		2.3	3.6			1.55	0.33	0.21
METAL-CLP-NONCLP	SILVER	UG/L	LT-CR	B		34		0.1			6.00			
METAL-CLP-NONCLP	SILVER	UG/L	LT-LK	B		135		0.1			10.00			
METAL-CLP-NONCLP	SILVER	UG/L		B	14	116	0.12	2	10	2.10	7.20	2.49	1.56	0.63
METAL-CLP-NONCLP	SILVER	UG/L	CREEK	S	0	8	0.00	2.1	3.6			1.28	0.33	0.26
METAL-CLP-NONCLP	SILVER	UG/L	200	S		19		2.1	3.6			1.44	0.35	0.24
METAL-CLP-NONCLP	SILVER	UG/L	201	S		16		2.3	3.6			1.43	0.33	0.23
METAL-CLP-NONCLP	SILVER	UG/L	202	S		13		2.3	3.6			1.55	0.33	0.21
DMETAL-CLP-NONCLP	SODIUM	UG/L		B	151	152	0.99	17100	17100	4190.00	44700.00	17045.66	7281.65	0.43
DMETAL-CLP-NONCLP	SODIUM	UG/L	CREEK	S	3	3	1.00			5370.00	14200.00	8946.67	4647.65	0.52
DMETAL-CLP-NONCLP	SODIUM	UG/L	200	S	16	16	1.00			5370.00	8610.00	7980.00	745.48	0.09
DMETAL-CLP-NONCLP	SODIUM	UG/L	201	S	18	18	1.00			7270.00	14200.00	11770.56	1326.77	0.11
DMETAL-CLP-NONCLP	SODIUM	UG/L	202	S	13	13	1.00			27100.00	32500.00	29761.54	1875.07	0.06
METAL-CLP-NONCLP	SODIUM	UG/L		B	154	155	0.99	5000	5000	3700.00	45400.00	16568.90	7500.07	0.45
METAL-CLP-NONCLP	SODIUM	UG/L	CREEK	S	8	8	1.00			4610.00	40000.00	12688.00	11709.00	0.92
METAL-CLP-NONCLP	SODIUM	UG/L	200	S	19	19	1.00			4610.00	40000.00	9351.05	7531.34	0.81
METAL-CLP-NONCLP	SODIUM	UG/L	201	S	20	20	1.00			6940.00	415000.00	31817.00	90201.58	2.84
METAL-CLP-NONCLP	SODIUM	UG/L	202	S	13	13	1.00			27000.00	31200.00	29076.92	1494.52	0.05
DMETAL-CLP-NONCLP	STRONTIUM	UG/L		B	112	138	0.81	100	1000	39.90	438.00	190.86	145.58	0.76
DMETAL-CLP-NONCLP	STRONTIUM	UG/L	CREEK	S	3	3	1.00			96.20	189.00	129.01	51.98	0.40
DMETAL-CLP-NONCLP	STRONTIUM	UG/L	200	S	16	16	1.00			96.20	147.00	130.45	13.03	0.10
DMETAL-CLP-NONCLP	STRONTIUM	UG/L	201	S	18	18	1.00			102.00	189.00	159.00	16.95	0.11
DMETAL-CLP-NONCLP	STRONTIUM	UG/L	202	S	13	13	1.00			114.00	137.00	124.62	7.54	0.06
METAL-CLP-NONCLP	STRONTIUM	UG/L		B	117	135	0.87	100	1000	37.40	408.00	177.31	130.50	0.74
METAL-CLP-NONCLP	STRONTIUM	UG/L	CREEK	S	8	8	1.00			77.90	306.00	150.61	77.86	0.52
METAL-CLP-NONCLP	STRONTIUM	UG/L	200	S	19	19	1.00			77.90	306.00	135.66	45.80	0.34
METAL-CLP-NONCLP	STRONTIUM	UG/L	201	S	20	20	1.00			98.40	186.00	157.42	17.74	0.11
METAL-CLP-NONCLP	STRONTIUM	UG/L	202	S	13	13	1.00			114.00	132.00	122.69	6.01	0.05
DMETAL-CLP-NONCLP	THALLIUM	UG/L		B	2	97	0.02	0.9	15	1.20	1.20	1.63	1.48	0.90
DMETAL-CLP-NONCLP	THALLIUM	UG/L	CREEK	S	0	3	0.00	0.9	0.9			0.45		

B = Background CL-CR = Literature Values, streams
 S = OU 3 (onsite) LT-CK = Literature Values, lakes/reservoirs

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SURFACE WATER PCOCS

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MAIN TEST GROUP CODE	CHEMICAL NAME	NEW UNIT	IHSS	AREA	NUMBER OF DETECTS	NUMBER OF SAMPLES	FREQUENCY OF DETECTION	MINIMUM NONDETECTED VALUE	MAXIMUM NONDETECTED VALUE	MINIMUM DETECTED VALUE	MAXIMUM DETECTED VALUE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
DMETAL-CLP-NONCLP	THALLIUM	UG/L	200	S		16		0.9	4.3			1.82	0.48	0.26
DMETAL-CLP-NONCLP	THALLIUM	UG/L	201	S		18		0.9	1.6			0.64	0.12	0.19
DMETAL-CLP-NONCLP	THALLIUM	UG/L	202	S		13		0.9	4.5			1.16	0.69	0.60
METAL-CLP-NONCLP	THALLIUM	UG/L		B	3	124	0.02	0.6	40	1.60	3.40	1.68	2.15	1.28
METAL-CLP-NONCLP	THALLIUM	UG/L	CREEK	S	0	8	0.00	0.9	1.8			0.67	0.21	0.31
METAL-CLP-NONCLP	THALLIUM	UG/L	200	S		19		0.9	4.3			1.68	0.56	0.33
METAL-CLP-NONCLP	THALLIUM	UG/L	201	S		20		0.9	1.6			0.64	0.11	0.18
METAL-CLP-NONCLP	THALLIUM	UG/L	202	S		13		0.9	4.5			1.23	0.77	0.62
DMETAL-CLP-NONCLP	TIN	UG/L		B	17	98	0.17	9.3	136	10.80	72.40	27.74	21.15	0.76
DMETAL-CLP-NONCLP	TIN	UG/L	CREEK	S	0	3	0.00	12.5	12.5			6.25		
DMETAL-CLP-NONCLP	TIN	UG/L	200	S		16		6.2	12.5			4.48	1.61	0.36
DMETAL-CLP-NONCLP	TIN	UG/L	201	S	5	17	0.29	6.2	12.5	6.30	13.70	7.01	3.09	0.44
DMETAL-CLP-NONCLP	TIN	UG/L	202	S	1	13	0.08	6.2	12.5	8.10	8.10	4.70	1.86	0.40
METAL-CLP-NONCLP	TIN	UG/L		B	18	118	0.15	7	136	11.00	180.00	19.61	22.01	1.12
METAL-CLP-NONCLP	TIN	UG/L	CREEK	S	0	8	0.00	6.2	12.5			4.88	1.31	0.27
METAL-CLP-NONCLP	TIN	UG/L	200	S	3	19	0.16	6.2	12.5	7.00	9.70	5.41	2.08	0.38
METAL-CLP-NONCLP	TIN	UG/L	201	S		20		6.2	12.5			4.52	1.61	0.36
METAL-CLP-NONCLP	TIN	UG/L	202	S	1	13	0.08	6.2	12.5	6.50	6.50	4.57	1.66	0.36
DMETAL-CLP-NONCLP	VANADIUM	UG/L		B	13	106	0.12	2	50	2.00	12.10	4.20	5.55	1.32
DMETAL-CLP-NONCLP	VANADIUM	UG/L	CREEK	S	0	3	0.00	3.3	3.3			1.65		
DMETAL-CLP-NONCLP	VANADIUM	UG/L	200	S	2	16	0.13	2.5	3.3	2.70	3.40	1.65	0.59	0.36
DMETAL-CLP-NONCLP	VANADIUM	UG/L	201	S		18		2.5	3.3			1.45	0.21	0.14
DMETAL-CLP-NONCLP	VANADIUM	UG/L	202	S	6	13	0.46	2.5	3.3	2.90	6.10	2.76	1.59	0.58
METAL-CLP-NONCLP	VANADIUM	UG/L		B	33	120	0.28	2	60	2.00	18.20	6.64	8.22	1.24
METAL-CLP-NONCLP	VANADIUM	UG/L	CREEK	S	2	8	0.25	2.5	3.5	3.80	4.80	2.29	1.28	0.56
METAL-CLP-NONCLP	VANADIUM	UG/L	200	S	10	19	0.53	2.5	3.5	2.80	8.00	3.15	2.08	0.66
METAL-CLP-NONCLP	VANADIUM	UG/L	201	S	1	20	0.05	2.5	3.3	3.80	3.80	1.56	0.56	0.36
METAL-CLP-NONCLP	VANADIUM	UG/L	202	S	6	13	0.46	2.5	3.3	2.50	6.40	2.60	1.56	0.60
DMETAL-CLP-NONCLP	ZINC	UG/L		B	86	138	0.62	1.7	44	2.40	111.50	14.08	18.21	1.29
DMETAL-CLP-NONCLP	ZINC	UG/L	CREEK	S	3	3	1.00			13.30	44.90	28.00	15.91	0.57
DMETAL-CLP-NONCLP	ZINC	UG/L	200	S	8	16	0.50	5.7	10.1	5.80	30.40	10.63	9.35	0.88
DMETAL-CLP-NONCLP	ZINC	UG/L	201	S	12	18	0.67	5.7	10.1	7.00	44.90	11.74	9.49	0.81
DMETAL-CLP-NONCLP	ZINC	UG/L	202	S	8	13	0.62	5.7	10.1	5.70	143.00	18.46	37.80	2.05
METAL-CLP-NONCLP	ZINC	UG/L	LT-CR	B		35		5			670.00			

B = Background LT-CR = Literature Values, streams

S = OU 3 (onsite) LT-CR = Literature Values, lakes/reservoirs

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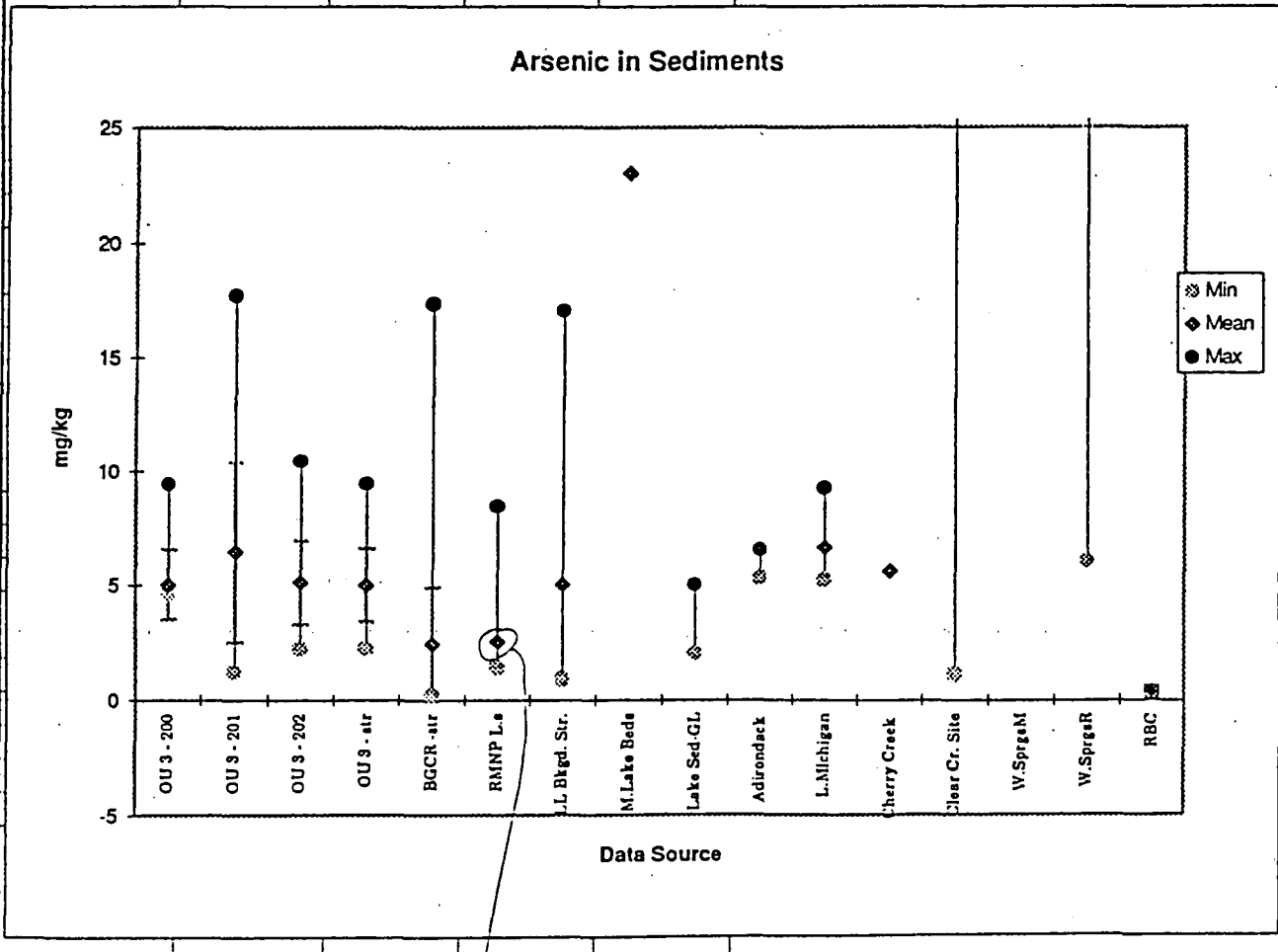
SURFACE WATER PCOCS

MAIN TEST GROUP	CHEMICAL NAME	NEW UNIT	IHSS	AREA	NUMBER OF DEFECTS	NUMBER OF SAMPLES	FREQUENCY OF DETECTION	MINIMUM NONDETECTED VALUE	MAXIMUM NONDETECTED VALUE	MINIMUM DETECTED VALUE	MAXIMUM DETECTED VALUE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
METAL-CLP-NONCLP	ZINC	UG/L	LT-LK	B		167				1.00	89.00			
METAL-CLP-NONCLP	ZINC	UG/L		B	104	151	0.69	1.7	60.4	1.90	480.00	32.74	62.29	1.90
METAL-CLP-NONCLP	ZINC	UG/L	CREEK	S	8	8	1.00			15.00	158.00	91.58	39.59	0.65
METAL-CLP-NONCLP	ZINC	UG/L		S	19	19	1.00			13.80	158.00	48.46	44.32	0.91
METAL-CLP-NONCLP	ZINC	UG/L		S	17	20	0.85	10.1	10.1	12.80	184.00	38.60	47.49	1.23
METAL-CLP-NONCLP	ZINC	UG/L		S	13	13	0.54	5.7	10.1	6.60	18.00	8.18	5.49	0.67

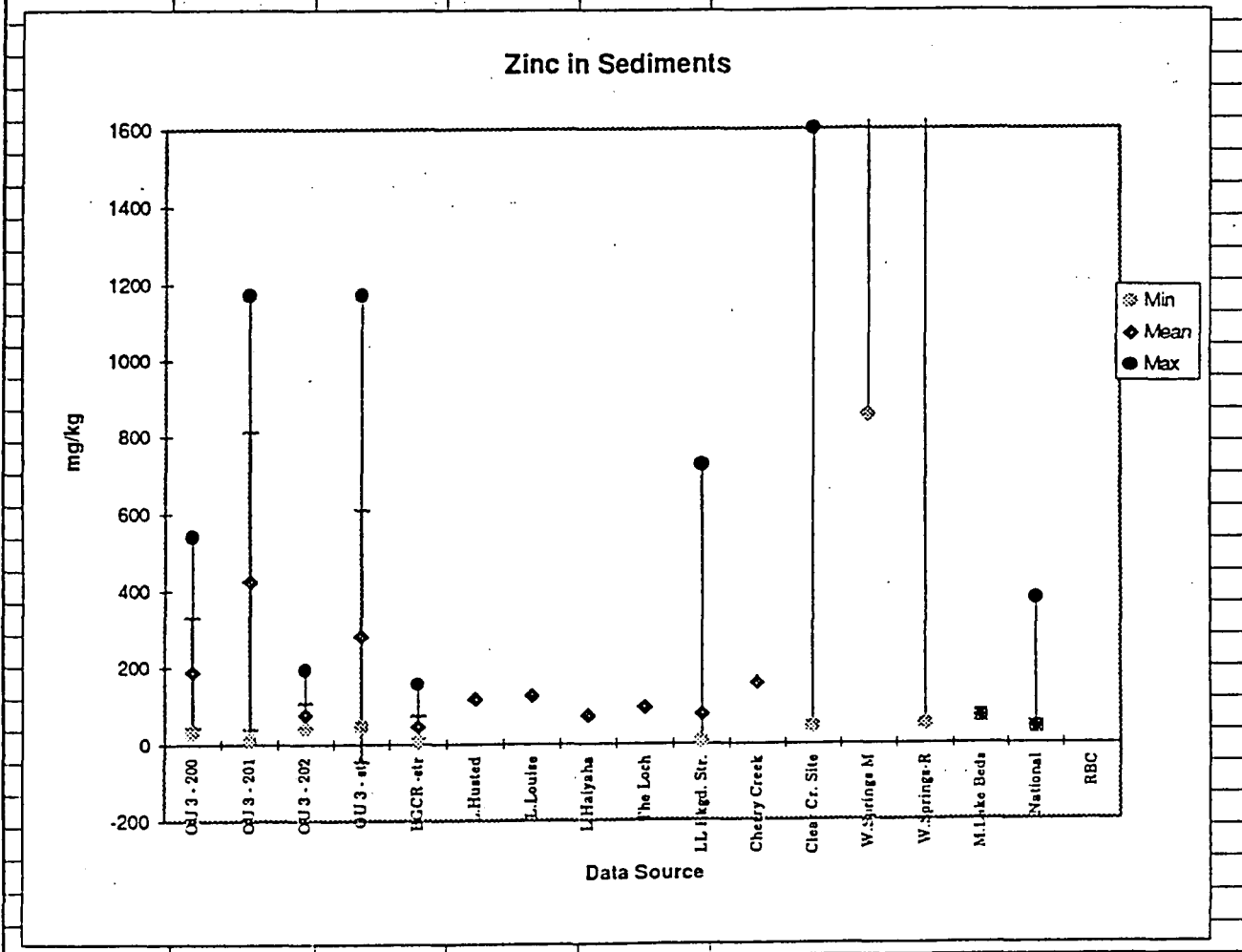
B = Background
S = OU 3 (onsite)
LT-CR = Literature Values, streams
LT-CK = Literature Values, lakes/reservoirs

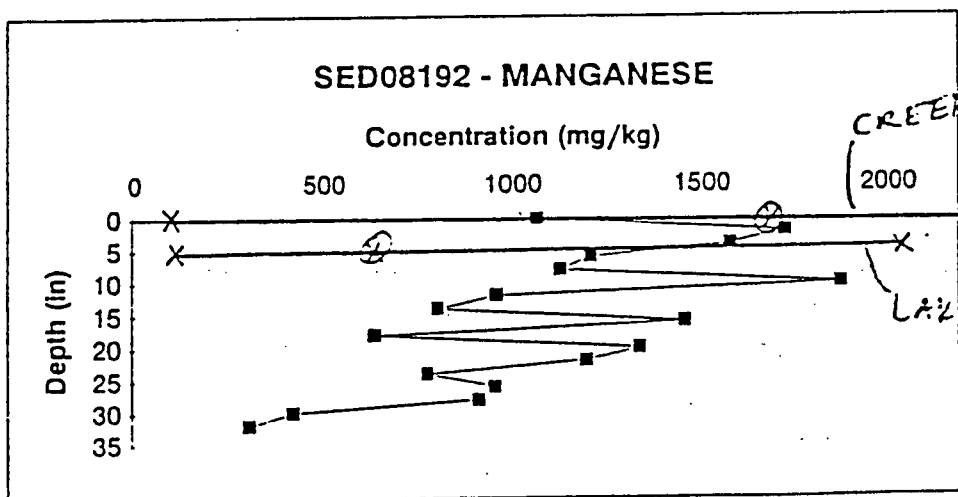
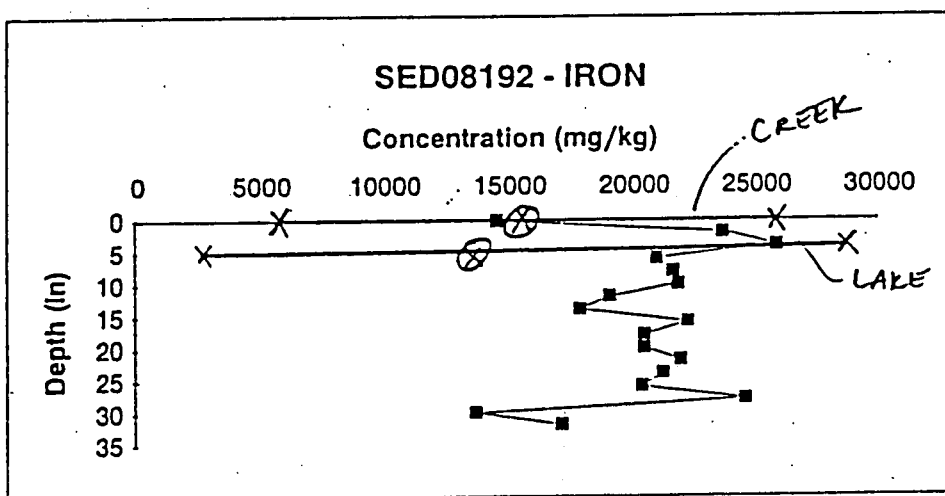
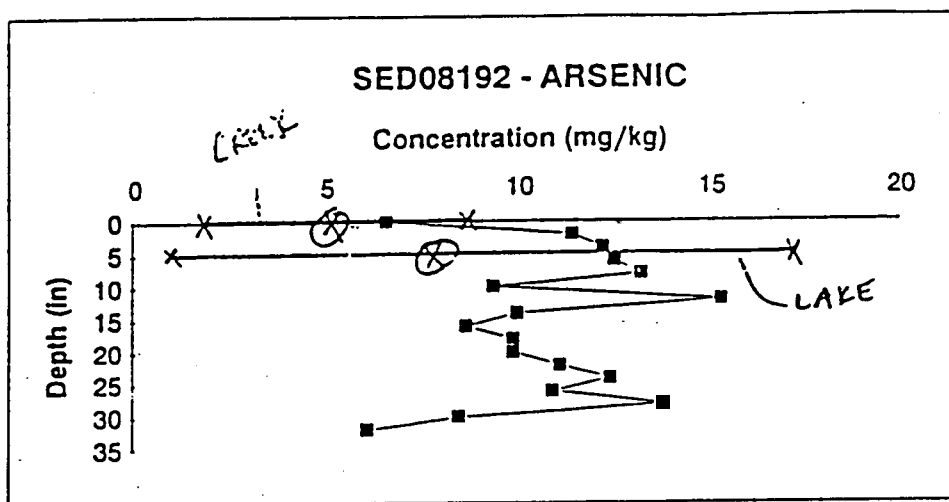
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Arsenic in Sediments					
mg/kg					
Sediment Data Set	Min	Mean	Max	Std Dev	Source
OU 3 - 200	4.6	5	9.4	1.52	DA042694.db (RFEDS - 4/94)
OU 3 - 201	1.2	6.42	17.7	3.95	DA042694.db (RFEDS - 4/94)
OU 3 - 202	2.2	5.09	10.4	1.84	DA042694.db (RFEDS - 4/94)
OU 3 - str	2.2	4.95	9.4	1.59	DA042694.db (RFEDS - 4/94)
BGCR -str	0.2	2.4	17.3	2.45	Background Geochemical Characterization Report
RMNP L.s	1.4	2.5	8.4		RMNP Lakes (Husted, Louise, Haiyaha, The Loch)
LL Bkgd. Str.	0.9	5	17		Lowry Landfill OUs 2-5 Baseline Risk Assessment
M.Lake Beds		23			Missoula Lake Beds (No Contamination) (Moore 1985)
Lake Sed-GL	2		5		Great Lakes range, Fergusson, 1990
Adirondack	5.3		6.5		Fergusson, 1990
L.Michigan	5.2	6.6	9.2		Fergusson, 1990
Cherry Creek		5.57			Cherry Creek Reservoir
Clear Cr. Site	1.1		46		Clear Creek Superfund Site
W.SprgsM	42		590		Warm Springs Pond Superfund Site (Range of Means)
W.SprgsR	6		1910		Warm Springs Pond Superfund Site (Range)
RBC		0.36			10-6 Risk Based Concentration Level - WORST CASE



Zinc in Sediments					
mg/kg					
Sediment Data Set	Min	Mean	Max	Std Dev	Source
OU 3 - 200	28.5	186.934	540	143.36	DA042694.db (RFEDS - 4/94)
OU 3 - 201	9	424.77	1170	387.134	DA042694.db (RFEDS - 4/94)
OU 3 - 202	40.5	74.5579	193	33.419	DA042694.db (RFEDS - 4/94)
OU 3 - str	44.6	280.85	1170	327.48	DA042694.db (RFEDS - 4/94)
BGCR -str	3.25	43.77	155	30.23	Background Geochemical Characterization Report
L.Husted		117			RMNP
L.Louise		125			RMNP
L.Haiyaha		72			RMNP
The Loch		95			RMNP
LL Bkgd. Str.	6	77	726		Lowry Landfill OUs 2-5 Baseline Risk Assessment
Cherry Creek		158			Cherry Creek Reservoir
Clear Cr. Site	44		1600		Clear Creek Superfund Site
W.Springs M	855		17319		Warm Springs Pond Superfund Site (Range of Means)
W.Springs-R	49		28200		Warm Springs Pond Superfund Site (Range)
M.Lake Beds		70			Missoula Lake Beds (No Contamination) (Moore 1985)
National		41	379		National Median and UCL95
RBC		82000			Risk Based Concentration Level - NonCancer





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Stream Sediments
RFP 0U 3

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Stream Sediments RFP OU 3

All Stream Sed												
Radionuclides	IHSS 200			IHSS 201			IHSS 202			Rio Grande (Purtyman, et al, 1990)		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Min	Mean	Max
Am-241	0	0.04	0.21	0	0.02	0.11	0.01	0.05	0.09			
Pu-239/240	0	0.26	3.3	-0.02	0.04	0.55	0.03	0.25	0.49	0.001	0.0045	0.0088
Ra-226	0.84	1.11	2.2	0.28	0.79	1.4	na	na	na			
Sr-89/90	0.11	0.291	0.57	0.14	0.326	0.72	na	na	na			
Tritium	-81	780	9300	77	112	159.6	na	na	na			
U-233/234	0.32	1.35	5.4	0.22	1.3	4.7	0.66	1.38	3.5			
U-235	0	0.071	0.56	-0.0016	0.054	0.2	0.01	0.07	0.17			
U-238	0.31	1.35	4.4	0.2	1.26	3.9	0.79	1.44	3.3			
N:												

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[illegible]

Stream Sediments
RFP OU 3

[illegible]

**Stream Sediments
RFP OU 3**

Background													
OU 3													
Geochemical Characterization Report													
Ratio													
Ratio													
Stream Sediment													
Stream Sediment													
Minimum Mean Maximum													
[mg/kg] [mg/kg] [mg/kg]													
OU 3 Mean to OU 3 Max to													
Bkgd GC Mean Bkgd GC Max													
Metals	No. of Significant Tests	Stats PCOC?	n	hits	DF	Minimum	Mean	Maximum	Minimum [mg/kg]	Mean [mg/kg]	Maximum [mg/kg]	OU 3 Mean to Bkgd GC Mean	OU 3 Max to Bkgd GC Max
Aluminum	1	Y	26	26	100%	1900	8585	33200	549	5888	25200	1.46	1.32
Antimony	1	Y	25	7	28%	1.8	5.3	16.5	0.8	3.3	12.4	1.62	1.33
Arsenic	3	Y	26	26	100%	2.2	5.0	9.4	0.2	2.4	17.3	2.05	0.54
Barium	3	Y	26	26	100%	78.6	146	329	10.6	78	244	1.87	1.35
Beryllium	1	Y	26	26	100%	0.22	0.69	1.6	0.03	0.66	13	1.05	0.12
Cadmium	2	Y	26	10	38%	0.21	1.24	6.3	0.13	0.54	2.05	2.30	3.07
Calcium	4	Y	26	26	100%	911	13262	75000	93.5	3658	17100	3.63	4.39
Chromium	0	N	26	24	92%	0.19	8.19	31.9	0.48	8.13	29.2	1.01	1.09
Cobalt	2	Y	26	26	100%	2.9	8.92	23.3	0.3	5.04	15	1.77	1.55
Copper		N	26	26	100%	7.3	24.34	52.3	0.31	10.15	36.7	2.40	1.43
Gross Alpha	0	N	26	26	100%	8.3	20.06	43	2.92	22.98	72	0.87	0.60
Iron	3	Y	26	26	100%	5670	19188	51700	1040	8852	31400	2.17	1.65
Lead	2	Y	26	26	100%	5.3	28.98	91.4	2.1	22.02	244	1.32	0.37
Lithium	1	Y	26	26	100%	1.8	7.92	34.6	1.15	7.48	22.9	1.06	1.51
Magnesium	3	Y	26	26	100%	595	2516	9480	125.5	1474	5850	1.71	1.62
Mercury	nc	?	26	3	12%								
Manganese	5	Y	26	26	100%	83.5	1213	4450	9	228	1280	5.32	3.48
Molybdenum	1	Y	26	12	46%	0.35	3.98	17.9	0.33	4.47	22.9	0.89	0.78
Nickel	3	Y	26	24	92%	3.15	17.67	72.7	0.65	6.75	25.6	2.62	2.94
Potassium	2	Y	26	26	100%	548	1607	8390	57	835	3770	1.92	2.23
Selenium	0	N	26	9	35%	0.1	0.5	2.2	0.1	0.42	2.9	1.19	0.75
Silver	2	Y	26	16	62%	0.25	1.36	4	0.2	0.66	3.4	2.06	1.18
Sodium	2	Y	26	25	100%	51.5	364	2490	28.8	162	705	2.25	3.53
Strontium	0	N	26	26	100%	15	74	349	2.8	36	421	2.06	0.83
Vanadium	2	Y	26	26	100%	11.2	30.2	87.7	2	18.33	73	1.65	1.20
Zinc	5	Y	26	26	100%	44.6	280.85	1170	325	43.77	155	6.42	7.55
No. of Stats PCOCs:			20										

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Stream Sediments RFP OU 3

Metals	IHSS 200			IHSS 201			IHSS 202			Median	National	National	National	National	Maximum
	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum						
Aluminum	2220	40424	20800	852	9392	33200	7480	13708	18300						
Antimony	1.8	5.5	13.2				4.6	12.24	44.4						
Arsenic	4.6	5.0	9.4	1.2	6.42	17.7	2.2	5.09	10.4						
Barium	39	130	243	10.8	113	329	81.5	168	296						
Beryllium	0.24	0.85	1.6	0.06	0.67	1.6	0.41	1.01	1.5						
Cadmium	0.2	0.57	1.7	0.18	1.74	6.3									
Calcium	7519	15700	33900	427	9515	90100	6480	16655	59400						
Chromium	0.19	9.85	19.8	0.22	9.63	31.9	4.4	14.35	22.1						
Cobalt	23.3	9.13	3.5	1.3	7.26	13.2	4.4	8.24	15.3						
Copper	8.1	43.47	129	1.2	58.7	183	7.3	23.5	50.1	4	YES	32	YES		
Gross Alpha	3.8	23.43	37	1.2	18.9	39	15	31.2	84						
Iron	4670	18512	53900	3100	14997	28300	10800	19742	48000						
Lead	5.3	29.03	88.2	2.9	57.5	317	12.3	27.2	40.8	16	YES	199	NO		
Lithium	1.8	8.54	17.6	0.24	7.7	34.6	7	10.69	16.2						
Magnesium	684	2769	5140	197	2646	9480	2270	3816	5040						
Mercury	na	na		0.1	0.6										
Manganese	40.5	473	1550	83.5	868	4450	148	350	1170						
Molybdenum	0.24	3.94	17.9	0.2	2.04	7.7									
Nickel	5.7	17.43	72.7	1.2	12.95	23.7	3.55	16.14	29.9	13	YES	99	NO		
Potassium	402	1508	2700	183	1749	8390	1210	2550	3450						
Selenium	0.1	0.78	4	0.1	0.8	4.5	0.11	1.31	5.7						
Silver	0.26	2	6	0.23	1.69	7.7	0.43	1.2	3.6						
Sodium	43.2	317	2490	26	175	1610	171	353	1080						
Strontium	15	57.4	154	28	54.1	423	35.8	93	349						
Vanadium	9.1	32.2	87.7	4.9	24.7	60.9	18.6	41.8	114						
Zinc	28.5	187	540	9	425	1170	40.5	75	193	41	YES	379	YES		

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**Stream Sediments
RFP OU 3**

Rocky Mountain National Park Lakes - Heit, Klusek, and Baron (1984)						
	[mg/kg]					
	Subsurface Sediment			Surface Sediments		
Metals	Lake Husted	Lake Louise	Lake Husted	Lake Louise	Lake Haiyaha	The Loch
Aluminum						
Antimony						
Arsenic	0.79	1	2.5	2.5	8.4	1.4
Barium						
Beryllium	3.9	7.4	3.9	5	9.3	7.4
Cadmium	0.32	0.09	0.7	0.5	0.34	0.32
Calcium	12	25.5	25	34.1	54	47
Chromium						
Cobalt						
Copper						
Gross Alpha						
Iron	1100	1900	1600	2400	6200	2300
Lead	10	14	28	43	26	14
Lithium						
Magnesium						
Mercury	0.03	0.05	0.03	0.065	0.05	0.04
Manganese						
Molybdenum						
Nickel	4.2	9	9.5	10	12.3	18
Potassium						
Selenium	0.9	0.76	1.8	1.2	1.8	1.1
Silver						
Sodium						
Strontium						
Vanadium	15	32.8	27.3	35	55	43
Zinc	80	155	117	125	72	95
Nr						

**Stream Sediments
RFP OU 3**

	Lowry Landfill Background Data				Maximum								
	Stream Sediment				Literature	Maximum							
	[mg/kg]				Value	Greater Than		Background Data			Literature Data		
Metals	Minimum	Mean	Maximum	DF n	[mg/kg]	Max Literature		Range Comparable	Magnitude Difference	Mean < or Comparable	Amount of Lit. Data	Comparable to Lit Data	Magnitude Difference
Aluminum	1105	13959	32100	30	32100	YES		Yes	<2x	Yes	Few	NA	<2x
Antimony				30				Yes	<2x	Yes	Few	NA	<2x
Arsenic	0.9	5	17	26	17	NO		Yes	2x	?		?	2x
Barium	73	221	440	30	440	NO		Yes	<2x	Yes	Few	NA	<2x
Beryllium	0.23	1.04	2	30	9	NO		Yes	1x	Yes		Yes	<
Cadmium	0.2	1.04	4	30	12	NO		Yes	2x	Yes		Yes	2x
Calcium				30	54	YES		No	4x	No		No	>>
Chromium	2	12	23	30	23	YES		Yes	1x	Yes	Few	NA	NA
Cobalt	2	9	14	30	14	YES		Yes	<2x	Yes	Few	NA	NA
Copper	3	18	48	30	48	YES		Yes	<2x	Yes	Few	NA	NA
Gross Alpha				30				Yes	<2x	Yes	Few	NA	NA
Iron				30	6200	YES		Yes	2x	?	Few	NA	NA
Lead	0.001	28	380	30	380	NO		Yes	<2x	Yes		?	2x
Lithium				30				Yes	<2x	Yes	Few	NA	NA
Magnesium				30				Yes	<2x	Yes	Few	NA	NA
Mercury	0.05	0.08	0.29	30	1	NO							
Manganese	402	605	1560	21	1560	YES		?	5x	?	Few	NA	NA
Molybdenum				30				Yes	<2x	Yes	Few	NA	NA
Nickel	3	15	131	30	131	NO		Yes	2x	Yes		Yes	2x
Potassium				30									
Selenium				30	2	YES		Yes	1x	Yes		Yes	<
Silver	0.31	2	4	30	4	NO		Yes	<2x	Yes		Yes	<2x
Sodium				30				Yes	<2x	Yes	Few	NA	NA
Strontium				30				Yes	<2x	Yes	Few	NA	NA
Vanadium	12	33	73		73	YES		Yes	<2x	Yes	Few	NA	NA
Zinc	6	77	726	30	726	YES		Yes	7x	No		Yes	3x
Nr				30									

Reservoir Sediments
RFP OU 3

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OU 3											Stream Data from the Background					
Concentrations (pCi/g)											Geochemical Report			Colorado Lakes and Reservoirs		
Radionuclides	Stream Mean	200 Min	200 Mean	200 Max	201 Min	201 Mean	201 Max	202 Min	202 Mean	202 Max	Minimum	Mean	Maximum	Lo Mean	Hi Mean	
Am-241	0.02	0	0.04	0.21	0	0.02	0.11	0.01	0.05	0.09	-0.01	0.07	0.82			
Pu-239/240	0.11	0	0.26	3.3	-0.02	0.04	0.55	0.03	0.25	0.49	0	0.17	2.36	0.019	0.13	Pu-239
Ra-226	1.07	0.84	1.11	2.2	0.28	0.79	1.4	NA	NA	NA	0.43	0.85	1.8			
Sr-89/90	0.22	0.11	0.281	0.57	0.14	0.326	0.72	NA	NA	NA	-0.6	0.21	1.17			
Tritium	1237.98	-81	780	9300	77	112	159.6	NA	NA	NA	-23.2	155.87	380			
U-233/234	1.4	0.32	1.35	5.4	0.22	1.3	4.7	0.66	1.38	3.5	0.136	1.68	4.5	5.51	11.4	Total Uranium
U-235	0.08	0	0.071	0.56	-0.0016	0.054	0.2	0.01	0.07	0.17	0.4	0.06	0.19	5.51	11.4	Total Uranium
U-238	1.33	0.31	1.35	4.4	0.2	1.26	3.9	0.79	1.44	3.3	0.27	1.4	3.82	5.51	11.4	Total Uranium

Reservoir Sediments
RFP OU 3

Sterling/Greely Quad(n=56,52,105)																	
Phase I,II,III			Denver Quad (n=1060)			Greely Quad (n=984)			Wellington Lake								
Total Uranium Only			Total Uranium Only			Total Uranium Only			Depth, in								
Radionuclides	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8
Am-241																	
Pu-239/240										0.075	0.055	0.089	0.077	0.08	0.078	0.099	0.14
Ra-226																	
Sr-89/90																	
Tritium																	
U-233/234	I 2.4	5.79	31.2	1.1	11.4	164.3	1.8	9.4	108.4								
U-235	II 3.5	7.62	21.4														
U-238	II 2.7	5.51	18.8														

S. Colo & N. New Mexico Pu Mean Values
 Rio Grande Res. = 0.02 pCi/g
 Cochiti Res. = 0.02 pCi/g
 Heron Res. = 0.01 pCi/g
 El Vado Res. = 0.008 pCi/g
 Abiquiu Res. = 0.008 pCi/g

**Reservoir Sediments
RFP OU 3**

Radionuclides	8-9	9-10	10-11	11-12
Am-241				
Pu-239/240	0.12	0.12	0.19	0.14
Ra-226				
Sr-89/90				
Tritium				
U-233/234				
U-235				
U-238				

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Reservoir Sediments
RFP OU 3

	Halligan Reservoir												
	Depth, in												
Radionuclides	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	
Am-241													
Pu-239/240	0.019	0.028	0.024	0.018	0.028	0.046	0.017	0.018	0.032	0.036	0.033	0.039	
Ra-226													
Sr-89/90													
Tritium													
U-233/234													
U-235													
U-238													

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Reservoir Sediments
RFP OU 3

Colorado Reservoirs												
	CC Res		Marston Lake		Ralston Res.		Pueblo Quad. (n=1060)			Sterling Quad		
	Plutonium-239 Only						Total Uranium Only			Total Uranium Only		
Radionuclides	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Am-241												
Pu-239/240	<0.01	<0.05	<0.02	0.13	<0.03	0.06						
Ra-226												
Sr-89/90												
Tritium												
U-233/234							0.9	7.08	226.4	3.1	8.44	28
U-235												
U-238												

[illegible]

**Reservoir Sediments
RFP OU 3**

Metals	OU 3										Stream Data from the Background				
	Concentrations (pCi/g)										Geochemical Report			Cherry Creek	
	Mean	200 Min	200 Mean	200 Max	201 Min	201 Mean	201 Max	202 Min	202 Mean	202 Max	Minimum	Mean	Maximum		Reservoir
														n=1	
Aluminum	8585	2220	40424	20800	852	9392	33200	7480	13708	18300	549	5888	25200		96700
Antimony	5.3	1.8	5.5	13.2				4.6	12.24	44.4	0.8	3.3	12.4	Arsenic - L. Michigan Min = 5.2 Mean = 6.6 Max = 9.2	
Arsenic	5.0	4.6	5.0	9.4	1.2	6.42	17.7	2.2	5.09	10.4	0.2	2.4	17.3		5.57
Barium	146	38	130	243	10.8	113	329	81.5	168	296	10.6	78	244		591
Beryllium	0.69	0.24	0.85	1.6	0.06	0.67	1.6	0.41	1.01	1.5	0.03	0.66	13		4.03
Cadmium	1.24	0.2	0.57	1.7	0.18	1.74	6.3				0.13	0.54	2.05		0.05
Calcium	13262	7519	15700	33900	427	9515	90100	6480	16655	59400	93.5	3658	17100		
Chromium	8.19	0.19	9.85	19.8	0.22	9.63	31.9	4.4	14.35	22.1	0.48	8.13	29.2		
Cobalt	8.92	23.3	9.13	3.5	1.3	7.26	13.2	4.4	8.24	15.3	0.3	5.04	15		21.3
Copper	24.34	8.1	43.47	129	1.2	58.7	183	7.3	23.5	50.1	0.31	10.15	36.7		43.4
Gross Alpha	20.06	3.8	23.43	37	1.2	18.9	39	15	31.2	84	2.92	22.98	72		
Iron	19188	4670	18512	53900	3100	14997	28300	10800	19742	48000	1040	8852	31400		49700
Lead	28.98	5.3	29.03	88.2	2.9	57.5	317	12.3	27.2	40.8	2.1	22.02	244		55
Lithium	7.92	1.8	8.54	17.6	0.24	7.7	34.6	7	10.69	16.2	1.15	7.48	22.9		
Magnesium	2516	684	2769	5140	197	2646	9480	2270	3816	5040	125.5	1474	5850		
Mercury	na	na	na			0.1	0.6								0.06
Manganese	1213	40.5	473	1550	83.5	868	4450	148	350	1170	9	223	1280		739
Molybdenum	3.53	0.24	3.94	17.9	0.2	2.04	7.7				0.33	4.47	22.9		22
Nickel	17.67	5.7	17.43	72.7	1.2	12.95	23.7	3.55	16.14	29.9	0.65	6.75	25.6		25.2
Potassium	1607	402	1508	2700	183	1749	8390	1210	2560	3450	57	835	3770		15100
Selenium	0.5	0.1	0.78	4	0.1	0.8	4.5	0.11	1.31	5.7	0.1	0.42	2.9		1.1
Silver	1.36	0.26	2	6	0.23	1.69	7.7	0.43	1.2	3.6	0.2	0.66	3.4		0.05
Sodium	364	43.2	317	2490	26	175	1610	171	353	1080	28.8	162	705		
Strontium	74	15	57.4	154	2.8	54.1	423	35.8	93	349	2.8	36	421		202
Vanadium	30.2	9.1	32.2	87.7	4.9	24.7	60.9	18.6	41.8	114	2	18.33	73		115
Zinc	280.85	28.5	37	540	9	425	1170	40.5	75	193	325	43.77	155		158
No. of Stats PCOCs															

Reservoir Sediments RFP OU 3

Metals		Fergusson, 1990										BMNP Lakes - Hell, Klusek, and Baron (1984)									
		Clear Creek Site		Adirondack Lakes Near Natural		Niagara River Polluted		Illinois River Near Natural/Industrial		Subsurface Sediment		Surface Sediments		The Loch		Background Data					
		Min	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Lake Husted	Lake Louise	Lake Husted	Lake Louise	Lake Husted	Lake Louise	Range Comparable	Magnitude Difference				
Aluminum	84		8400													Yes	<2x				
Antimony																Yes	<2x				
Arsenic	1.1		46	5.3	6.5	2.7	14			0.79	1	2.5	2.5	8.4	1.4	Yes	2x				
Barium																Yes	<2x				
Beryllium										3.9	7.4	3.9	5	9.3	7.4	Yes	1x				
Cadmium	3.4		180	1.5	2.1	0.4	5.6	0.2	12.1	0.32	0.09	0.7	0.3	0.34	0.32	Yes	2x				
Calcium										12	26.5	26	34.1	54	47	No	4x				
Chromium	2.8		140													Yes	1x				
Cobalt																Yes	<2x				
Copper	1.6		120													Yes	<2x				
Gross Alpha																Yes	<2x				
Iron	6630		4600							1100	1900	1600	2400	6200	2300	Yes	2x				
Lead	11		410			6	157	3	140	10	14	28	43	26	14	Yes	<2x				
Lithium																Yes	<2x				
Magnesium																Yes	<2x				
Mercury						0.1	868			0.03	0.05	0.03	0.065	0.05	0.04	?	5x				
Manganese	170		8000													Yes	<2x				
Molybdenum																Yes	2x				
Nickel	5.3		190							4.2	9	9.6	10	12.3	18	Yes	2x				
Potassium																					
Selenium				1.6	1.9					0.9	0.76	1.8	1.2	1.8	1.1	Yes	1x				
Silver	1		180													Yes	<2x				
Sodium																Yes	<2x				
Strontium																Yes	<2x				
Titanium										15	32.8	27.3	35	55	43	Yes	<2x				
Zinc	44		1600							80	155	117	125	72	95	Yes	<2x				
No. of Stats POCs:																Yes	<2x				

Reservoir Sediments
RFP OU 3

Metals				
			Literature Data	
	Mean < or Comparable	Amount of Lit. Data	Comparable to Lit. Data	Magnitude Difference
Aluminum	Yes	Few	NA	<2x
Antimony	Yes	Few	NA	<2x
Arsenic	?		?	2x
Barium	Yes	Few	NA	<2x
Beryllium	Yes		Yes	<
Cadmium	Yes		Yes	2x
Calcium	No		No	>>
Chromium	Yes	Few	NA	NA
Cobalt	Yes	Few	NA	NA
Copper	Yes	Few	NA	NA
Gross Alpha	Yes	Few	NA	NA
Iron	?	Few	NA	NA
Lead	Yes		?	2x
Lithium	Yes	Few	NA	NA
Magnesium	Yes	Few	NA	NA
Mercury				
Manganese	?	Few	NA	NA
Molybdenum	Yes	Few	NA	NA
Nickel	Yes		Yes	2x
Potassium				
Selenium	Yes		Yes	<
Silver	Yes		Yes	<2x
Sodium	Yes	Few	NA	NA
Strontium	Yes	Few	NA	NA
Vanadium	Yes	Few	NA	NA
Zinc	Yes	Few	NA	NA
No. of Stats PCOCs	Yes	Few	NA	NA
	No		Yes	3x

Reservoir Sediments
RFP OU 3

SEDPCOC.XLS

Reservoir Sediments

RFP OU 3

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Reservoir Sediments
RFP OU 3

Metals						
Aluminum						
Antimony						
Arsenic						
Barium						
Beryllium						
Cadmium						
Calcium						
Chromium						
Cobalt						
Copper						
Gross Alpha						
Iron						
Lead						
Lithium						
Magnesium						
Mercury						
Manganese						
Molybdenum						
Nickel						
Potassium						
Selenium						
Silver						
Sodium						
Strontium						
Vanadium						
Zinc						
No. of Stats PCOCs						



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VIII

999 18th STREET, SUITE 500
DENVER, COLORADO 80202-2466

MAR 24 1994

Ref: 8HWM-FF

Mr. Richard Schassburger
U.S. Department of Energy
Rocky Flats Office
P.O. Box 928
Golden, CO 80402-0928

RE: Operable Unit 3
Comparisons to Background Data

Dear Mr. Schassburger:

Representatives of EPA, CDH, and DOE contractors met on March 10, 1994, to discuss options for comparing the remedial investigation data collected from Mower Reservoir, Standley Lake Reservoir, and Great Western Reservoir to background data. The intent of this letter is to document the agreement reached at this meeting.

EPA and CDH agree that a weight of evidence approach may be used to address the question of whether metals and radionuclides in the reservoirs are above background levels. The evidence considered should include, but may not be limited to the following:

1. A comparison of stream sediment data in the Operable Unit 3 (OU 3) drainages to background concentrations of stream sediments in the Background Geochemical Report. Those constituents above background in the drainages should be considered as potentially above background in the reservoirs.
2. A comparison of reservoir data to appropriate background values taken from the existing scientific literature.
3. A consideration of the results of remedial investigation sediment sampling in the Woman Creek and the Walnut Creek drainages (Operable Unit 5 and Operable Unit 6) to determine potential releases into the off site reservoirs.

We understand that this approach deviates from the standard protocol for making background comparisons at the Rocky Flats site which was recommended by Dr. Richard Gilbert of Battelle Pacific Northwest Laboratories and accepted by all three Interagency Agreement parties in a facilitated process (EPA letter dated October 25, 1993; CDH letter dated



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October 13, 1993). The protocol is highly statistically based. A key assumption is that the background data set is representative.

The available data characterizing background concentrations of reservoir sediments is sparse, therefore, a deviation from Dr. Gilbert's approach is warranted in the case of CU 3 reservoir sediments. In fact, we believe that if DOE were to use Dr. Gilbert's approach, the conclusions would be less supportable than a weight of evidence approach.

If there are any questions regarding this issue, please direct them to Bonnie Lavelle of EPA at (303) 294-1067, or Dave Norberry of CDH at (303) 692-3415.

Sincerely,

Martin Hestmark

Martin Hestmark, Manager
Rocky Flats Project

cc: Bob Birk, DOE
Mark Buddy, EG&G
Joe Schieffelin, CDH
Dave Norberry, CDH

Enclosure 5

**Overview of the chemicals of Concern Identification Process
Rocky Flats Environmental Technology Site
Human Health Risk Assessment
Operable Unit 3**

January 18, 1995

**OVERVIEW OF THE CHEMICALS OF CONCERN IDENTIFICATION PROCESS
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
HUMAN HEALTH RISK ASSESSMENT
OPERABLE UNIT 3**

January 18, 1995

- 1.0 INTRODUCTION
- 2.0 STATISTICAL COMPARISON TO BACKGROUND
 - 2.1 Selection of Data Sets
 - 2.2 Data Presentation
 - 2.3 Statistical Tests
 - 2.4 Professional Judgement
- 3.0 ESSENTIAL NUTRIENTS
- 4.0 DETECTION FREQUENCY
- 5.0 RBC COMPARISON
- 6.0 CONCENTRATION-TOXICITY SCREEN
- 7.0 PRG SCREEN
- 8.0 WEIGHT-OF-EVIDENCE EVALUATION
 - 8.1 Introduction
 - 8.2 Weight-of-evidence Evaluation Process
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 - 8.4.1 Spatial Analysis
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 - 8.4.3 Propability Plot Analysis
 - 8.4.4 Comparison of OU 3 Data to Benchmark Data
 - 8.4.5 Conclusions for the Weight-of-Evidence Evaluation
 - 8.5 Beryllium in Sediment
 - 8.5.1 Spatial Analysis
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 - 8.5.3 Propability Plot Analysis
 - 8.5.4 Comparison of OU 3 Data to Benchmark Data
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 - 8.6 Americium-241 in Sediment
 - 8.7 Arsenic in Groundwater

8.8 Beryllium in Groundwater

8.9 Uranium-233/234 in Groundwater

9.0 SUMMARY

10.0 REFERENCES

1.0 INTRODUCTION

The purpose of this document is to present an overview of the Chemicals of Concern (COC) selection process for Rocky Flats Environmental Technology Site (RFETS) Operable Unit 3 (OU 3) by presenting the methodology used to select COCs in TM 4 (DOE, 1994). The discussion of the process will focus on the list of COCs provided by EPA in their comments on TM 4 (EPA, 1995). Little emphasis is given to the selection of COCs for surface soils (IHSS 199) because there were not comments by EPA on the surface soil COCs. Information regarding the selection of COCs in surface soils is provided in Sections 3.0 and 4.0 of TM 4 (DOE, 1994).

The COC selection process identifies the chemicals detected in OU 3 that contribute significant potential risks to human receptors. The objective of the process is to identify those chemicals in a particular medium that, based on concentration and toxicity, contribute significantly to risks calculated for exposure scenarios involving that medium (EPA, 1989). The COCs will be used in the HHRA for OU 3 to quantify risks associated with exposure to environmental media. The COC selection process was agreed upon by EPA, CDPHE, and DOE and is based on Risk Assessment Guidance for Superfund (EPA, 1989), the Rocky Flats IAG between the State of Colorado (CDPHE), the U.S. Environmental Protection Agency (EPA), and the Department of Energy (DOE), January 1991 (IAG, 1991), and site-specific guidance (CDPHE/EPA/DOE, 1994; CDPHE/EPA, 1993; DOE, 1993a; EPA, 1994).

The COC selection process, as specified by the EPA, CDPHE, and DOE, is outlined in Figure 1-1 and includes the following steps:

- Statistical comparison of site data to background data (Section 2.0)
- Elimination of essential nutrients (Section 3.0)
- Elimination of chemicals detected infrequently (less than 5 percent detection frequency) and less than 1,000 times a risk-based concentration (Sections 4.0 and 5.0)
- Concentration-Toxicity screen (Section 6.0)
- Comparison to Preliminary Remediation Goals (PRGs) (Section 7.0)
- Weight-of-evidence evaluation (Section 8.0)

According to the RFETS COC selection process guidance (CDPHE/EPA/DOE, 1994), COCs are selected using all data, for a particular medium, from an operable unit. However, for OU 3, the selection of COCs on an OU-wide basis is not appropriate based on spatial, exposure, physical processes, and hydrologic differences (A discussion of these factors is provided in Subsection 2.1). Therefore, on the basis of these factors, the remaining sections address the selection of COCs on an IHSS-by-IHSS basis.

2.0 STATISTICAL COMPARISON TO BACKGROUND

The purpose of this step of the COC selection process is to identify chemicals with concentrations or activities in OU 3 that are significantly greater than corresponding concentrations or activities in background. The term "background data" is used to represent the data collected and summarized in the BGCR (DOE, 1993c) and the Rock Creek surface soil data used in the statistical comparison tests. The statistical comparison methodology includes a data-presentation step and a series of statistical comparison tests that are performed for each analyte. The statistical methodology for OU-to-background comparisons was agreed upon by EPA, CDPHE, and DOE (DOE, 1993a; EPA, 1993; DOE, 1994a; EG&G, 1994) and is based on site-specific guidance developed by Gilbert (1993).

2.1 Selection of Data Sets

All chemical data collected during the OU 3 field sampling program, as well as supplemental chemical data (Jefferson County Remedy Acres surface soil data and 1983/1984 sediment data from Great Western Reservoir and Standley Lake), were considered initially for the COC selection process. During the February 14, 1994 meeting, the treatment of subsurface core data in the COC selection process was discussed. It was decided by all parties that if the core data are not associated with an exposure pathway, the data do not need to be compared to background data for the risk assessment. Subsurface sediments in Great Western Reservoir were included because of the possibility that the reservoir may be drained and could be converted to residential, recreational, or commercial/industrial land uses thereby disturbing the subsurface sediments during construction activities.

Statistical tests are performed only after the data have been prepared and meet requirements for statistical analysis (Gilbert, 1993; CDPHE/EPA, 1993; DOE, 1993). After evaluating the OU 3 and existing background data sets (i.e., groundwater, sediment, and surface-water background data in Background Geochemical Characterization Report [BGCR] [DOE, 1993c] and Rock Creek surface-soil background data [DOE, 1993e]), the statistical comparison methodology was only used for

OU 3 surface-soil data. The explanation why the statistical tests were not applied to specific media was presented in the May 3, 1994 meeting and is described in the following paragraphs.

The comparability of data sets for rigorous statistical tests is important for reliable statistical findings (Gilbert, 1993). The results of the statistical tests using the background and OU 3 data sets in the BGCR (DOE, 1993c) for sediment, surface water, and groundwater were not plausible or conclusive. This consideration is based on a variety of factors. OU 3 data sets for reservoir sediments and surface water represent different environmental conditions and flow regimes than the stream background data sets -- no reservoir background data were available. The majority of OU 3 samples for surface water and sediment were collected from reservoirs, and the BGCR data for sediment and surface water were collected from streams. Too few surface water samples were collected in the streams in each IHSS (eight total samples for all three IHSSs combined) and the stream sediments (8, 14, and 4 samples respectively for IHSS 200, 201, and 202) to perform a valid statistical analysis on an IHSS-by-IHSS basis. The Gilbert process statistical tests were evaluated in a preliminary fashion for the stream sediment data, however, as Gilbert suggests, the results were determined implausible based on the reasons provided in Table 2-1 (this information was discussed during the May 3, 1994 meeting with EPA, CPDHE, and DOE).

While the background groundwater data set is composed of data collected from 49 wells (157 total samples), the OU 3 groundwater data were obtained from only 2 wells (sampled eight times each). Rigorous statistical comparisons would not be valid when comparing the results of 2 wells to 49 wells. In addition, the wells designated as background represent different environmental conditions and groundwater flow regimes. Also, the groundwater data were not collected to characterized the aquifers within OU 3. Groundwater sample analyses results from the two monitoring wells exhibit differences in groundwater chemistry between the two well locations. The results show differences from the wells in the BGCR (DOE, 1993) which are likely due to variations in water chemistry exhibited by different aquifers. Since the OU 3 monitoring wells are located in different hydrogeologic conditions than the BGCR wells, the data are not directly compatible. These results are illustrated on the Piper diagram presented in TM 4 (see Figure 8-13) and were discussed in the May 3, 1994 meeting.

It should be noted that it is possible to conduct the statistical tests for these media. There are at least four samples for most media by IHSS (see Table 2-1) and it is possible to run the Gilbert process with so few samples even though the power of the tests may not provide a good level of comfort. However, the uncertainty introduced by so few samples regarding the results of the tests is likely greater than the uncertainty in the WOE Evaluation. The WOE Evaluation uses a variety of information and analyses rather than tests that may or may not accurately reflect conditions at OU

3. The results of the statistical tests would be inconclusive or implausible based on knowledge of conditions in OU 3. As is allowed for in Gilbert's flow chart, the WOE evaluation would be performed.

According to the RFETS COC selection process guidance (CDPHE/EPA/DOE, 1994), COCs are selected using all data, for a particular medium, from an operable-unit. However, for OU 3, the selection of COCs on an OU-wide basis is not appropriate based on spatial, exposure, physical processes, and hydrologic differences. Therefore, COCs were selected on an IHSS-basis. The following points support selection of COCs on an IHSS-by-IHSS basis:

- Performing the concentration-toxicity screen on an IHSS-by-IHSS basis is the *most conservative approach* because it provides opportunity for more compounds to be retained as COCs in the detection-frequency screen. Non-detected data from one IHSS may contribute to lower the overall detection frequency below five percent and eliminate the chemical as a COC. Because of this artifact, a chemical detected greater than five percent of the time in one IHSS, may be eliminated as a COC.
- Performing the concentration-toxicity screen on an IHSS-by-IHSS basis is the *most conservative approach* because it provides opportunity for more compounds to be retained as COCs in the concentration-toxicity screen. For the entire OU data set, the maximum concentrations for arsenic and beryllium would represent the top 99 percent of the concentration-toxicity score excluding many other chemicals. However, in IHSSs that have smaller maximum concentrations, other chemicals may contribute to the top 99 percent of the concentration-toxicity score and pass the screen (i.e., be retained). As an example, the maximum arsenic sediment concentrations are as follows: 9.4 mg/kg in IHSS 200, 17.7 mg/kg in IHSS 201, and 10.4 mg/kg in IHSS 202. Using the arsenic concentration in IHSS 201 as the maximum OU 3 arsenic concentration, it would contribute almost 50% more to the concentration-toxicity score than if the 9.4 mg/kg and 10.4 mg/kg values were used on an individual IHSS basis.
- Each IHSS represents a distinct geographic location that is 1 to 2 miles from the other IHSSs. From a demographic and exposure perspective, different populations would likely frequent different reservoirs and it is not reasonable to aggregate the data in manner that is inconsistent with exposure patterns. Consideration of population dynamics in the HHRA is discussed in EPA Guidance (EPA, 1989).

- Potential background, RFETS-related, and other anthropogenic sources of metals concentrations are different (e.g., Clear Creek Superfund site, mineral deposits, other commercial, industrial, or agricultural sources). These factors introduce much uncertainty when making comparisons to background by the Gilbert process or the WOE evaluation.
- The source of water for each IHSS are from different watersheds. Mower Reservoir receives 100 percent of its water from the RFETS drainage basin, while Great Western Reservoir receives only 25 to 35 percent and Standley Lake receives only 5 to 10 percent.
- Exposure scenarios will differ between the IHSSs. For example, Great Western Reservoir may be drained, exposing the surface and potentially the subsurface sediments, while Standley Lake and Mower Reservoir will continue to be used for drinking water and irrigation purposes. Further, Standley Lake is widely used for recreation while Great Western is not and Mower is privately owned and used mainly for irrigation.

The ability to effectively communicate risk to the public will be complicated by OU 3-wide COCs . For example, additional effort would be required to explain to the public that plutonium in Standley Lake is not a problem (i.e., no $^{239/240}\text{Pu}$ activities exceed the 10^{-6} PRG), when it has been identified as a COC. COCs identified in each IHSS accomplish the purpose of the COC selection process-- focus the assessment on those chemicals that will contribute significantly to potential risks.

2.2 Data Presentation

The data-presentation step, as recommended by Gilbert (1993), is used to enhance the understanding and interpretation of the statistical tests; it graphically displays the background and OU 3 data sets and compares the magnitude, variability, and degree of their overlap. Several graphical data-presentation techniques were used to display the background and OU 3 data, including histograms, box plots, and probability plots. Probability plots are also an important component of the WOE evaluation (see Section 8.0).

2.3 Statistical Tests

Five statistical tests were performed only for the surface soil data for each analyte:

1. Hot-Measurement test
2. Gehan test
3. Quantile test
4. Slippage test
5. t-test

If any one of the statistical tests performed for a given comparison indicated a significant difference between OU 3 and background data, then the analyte was considered to be a Potential Chemical of Concern (PCOC) and professional judgement was applied to determine if the statistical results were plausible (Gilbert, 1993). Each of these statistical tests is based on different statistical hypotheses and assumptions. The purpose and method of each statistical test are briefly described in the following subsections. The hypothesis tested, test description, and assumptions made for each statistical test are described in detail. A description of these tests is provided in Subsection 3.1.2 in TM 4 (DOE, 1994). Results of the statistical comparison tests are presented in Appendix B of TM 4 (DOE, 1994).

2.4 Professional Judgement

The background-comparison methodology, as developed by Gilbert (1993), emphasizes evaluating the output of all statistical tests using professional judgement to determine if the results of the tests indicate contamination at the OU -- professional judgement is applied "to provide supporting evidence for accepting or rejecting the results of the screening and statistical tests." Specific guidance from EPA and CDPHE (EPA/CDPHE, 1993) limits this step to the following types of data evaluations:

- Spatial distribution--tools such as spatial plots and compound-specific mobility considerations
- Temporal distribution--tools such as time-series plots
- Pattern-recognition concepts--tools useful in identifying anomalies as well as confirming "fingerprint" associations.

The concepts discussed by Gilbert and included in the EPA-approved strawman were applied in the WOE Evaluation (performed as the last step of the COC selection process (Section 8.0)).

3.0 ESSENTIAL NUTRIENTS

The following inorganics were eliminated from all environmental media by this step of the COC selection process:

- Calcium
- Iron
- Magnesium
- Potassium
- Sodium

These nutrients are eliminated because they are considered an essential element in the diet (EPA, 1989).

If the EPA Region VIII Identification of Contaminants of Concern guidance (EPA, 1994) (comparing OU 3 concentrations to the recommended daily allowance and safe and adequate daily intake values) is followed, manganese, zinc, and copper would also be eliminated as COCs at this step. TM 4 does not reflect the use of this guidance--these chemicals were eliminated in other steps of the COC selection process.

4.0 DETECTION FREQUENCY

Chemicals that are infrequently detected may be artifacts in the data because of sampling or analytical problems and therefore may not be site-related (EPA, 1989). Detection frequencies for each chemical not eliminated by the first two steps of the COC selection process were evaluated by medium and IHSS. Chemicals that were not detected in any samples within a medium and IHSS were eliminated as COCs for that medium and IHSS. Chemicals detected in less than 5 percent of the samples for a medium within an IHSS were identified and further evaluated in an RBC comparison as described in Section 5.0.

Beryllium in Well 49292 was not detected in any of the eight samples and, therefore, was eliminated as a COC. Arsenic, beryllium, 239/240-plutonium, and 233/234-uranium in IHSS 200, 201, and 202 sediments and in IHSS 200 groundwater (Well 49192) were all detected greater than five percent of the time. These PCOCs are discussed in Section 6.0

5.0. RBC COMPARISON

Each chemical that had a detection frequency between zero and 5 percent was further evaluated to determine if the samples with results above detection limits represent potential areas of localized contamination. For this step, the maximum detected value for each chemical was compared to a Risk-Based Concentration (RBC). (RBCs are the same as PRGs, therefore, the term PRG will be used for the remainder of this document to eliminate confusion.) The PRGs used in this step are based on a residential exposure scenario for surface soil, sediment, and groundwater and were calculated based on the methodology presented in Programmatic Preliminary Remediation Goals (DOE, 1994b). For surface water, the PRGs are based on a recreational exposure scenario because any exposure to unfiltered surface water is assumed to occur through recreational use of the reservoirs. If the maximum detected value did not exceed 1,000 times the PRG, the chemical was eliminated as a COC. No chemicals in the OU 3 database (regardless of detection frequency) were found at levels 1,000 times the PRG. Thus, temporal analysis was not performed on any analyte and there are no special-case COCs for OU 3.

Chemicals without oral and inhalation toxicity values cannot be evaluated in the PRG screen. These chemicals were evaluated in the weight-of-evidence evaluation described in Subsection 3.7 of TM 4 and all were eliminated based on the results of the WOE process.

6.0 CONCENTRATION-TOXICITY SCREEN

The concentration-toxicity screen is used to identify the chemicals within each medium and IHSS that are most likely to contribute significantly to risks (i.e., the top 99 percent of the risk). The concentration-toxicity screen is performed for each medium by each of the three IHSSs in OU 3. The concentration-toxicity screen was performed following EPA guidance (EPA, 1989). However, the EPA Region VIII Contaminants of Concern Identification guidance (EPA, 1994) was also followed in that all chemicals exceeding a PRG were retained as PCOCs.

The first part of the screen was to calculate an individual risk factor for each chemical not eliminated by previous steps in the COC selection process. The chemical risk factor was calculated either by multiplying the maximum chemical concentration by the corresponding slope factor for carcinogens, or by dividing the maximum chemical concentration by the corresponding reference dose (RfD) for chemicals with noncarcinogenic effects. For chemicals with both oral and inhalation toxicity values, the more conservative toxicity factors (i.e., greater slope factor for carcinogens and lower RfD for chemicals with noncarcinogenic effects) were used to calculate the chemical risk factors.

The individual risk factors were then summed by medium and IHSS to obtain a total risk factor, according to the end point of toxicity (carcinogenic or noncarcinogenic effects). Radionuclide and nonradionuclide chemicals were summed separately because units for slope factors and concentrations/activities in environmental media are different for these two classes of chemicals. The ratio of each individual chemical risk factor to the total risk factor approximates the relative risk for that medium and IHSS due to each chemical. The chemicals whose combined ratios sum to 0.99 (99 percent) of the total risk were considered likely to contribute significantly to the overall risk. All other chemicals, except those with maximum concentrations exceeding the PRG, were eliminated as COCs.

Chemicals without oral or inhalation toxicity values cannot be evaluated in the concentration-toxicity screen step. The chemicals without toxicity values that were detected in OU 3 were evaluated further using a weight-of-evidence evaluation to determine if levels of the chemicals in OU 3 were elevated over background conditions. The results of this evaluation are included in the discussions of the weight-of-evidence evaluation in Subsections 5.6, 6.6, and 7.6 of TM 4 for sediment, surface water, and groundwater, respectively.

The results of the concentration-toxicity screen are included in Appendix D of TM 4 (DOE, 1994).

The following PCOCs passed the concentration-toxicity screen and were retained as PCOCs:

- ²⁴¹Am in sediment (all IHSSs)
- ²⁴¹Am in subsurface sediment (IHSS 200 only)
- Arsenic and beryllium in IHSS 200, 201, and 202 sediment
- Arsenic and beryllium in IHSS 200 subsurface sediment
- Arsenic and beryllium in IHSS 200 groundwater
- Arsenic in IHSS 201 groundwater
- U-233/234 in IHSS 200 groundwater
- U-233/234 in IHSS 201 groundwater

Again, beryllium was not detected in IHSS 201 groundwater.

7.0 PRG SCREEN

The chemicals remaining at this point in the COC selection process were evaluated further using the PRG screen. The PRGs were calculated based on the methodology presented in Programmatic Preliminary Remediation Goals (DOE, 1994b) and included in Attachment 1 of Appendix E of TM 4 (DOE, 1994). Any chemicals with maximum detected values less than the

corresponding PRG were eliminated as COCs. However, chemicals with maximum detected values greater than a PRG (regardless if they passed or failed the concentration-toxicity screen) were carried through the weight-of-evidence evaluation described in Section 3.7 of TM 4 (DOE, 1994) and Section 8.0 of this document. This step is consistent with the EPA Region VIII guidance (EPA, 1994) in retaining chemicals in the risk assessment that exceed the PRG. Beryllium in IHSS 200 surface sediments is the only chemical which failed the concentration-toxicity screen and is greater than the PRG. Beryllium was eliminated in the WOE evaluation.

The results of the PRG screen are included in Appendix E of TM 4.

The following PCOCs maximum concentrations do not exceed the PRG and were eliminated as COCs:

- Americum-241 in surface sediment for IHSS 200 (maximum activity = 0.2 pCi/g), IHSS 201 (0.1 pCi/g), and IHSS 202 (0.1 pCi/g) do not exceed the residential PRG (2.37 pCi/g).
- Americum-241 in subsurface sediment for IHSS 200 (1.0 pCi/g), does not exceed the construction scenario PRG (655 pCi/g).
- Arsenic in IHSS 200 subsurface sediment (maximum concentration = 10.4 mg/kg) does not exceed the construction scenario PRG (681 mg/kg)
- Uranium-233/234 in IHSS 201 groundwater does not exceed the residential PRG (0.87 vs. 2.98 pCi/L)

The following PCOCs maximum concentrations do exceed the PRG and are assessed in the WOE Evaluation:

- Arsenic in IHSS 200, 201, and 202 surface sediment (9.4, 17.7, and 10.4 mg/kg vs. 0.37 mg/kg)
- Beryllium in IHSS 200, 201, and 202 surface sediment grab samples (1.6, 1.6, and 1.5 mg/kg vs. 0.15 mg/kg)
- Arsenic and Beryllium in IHSS 200 groundwater (6.9 ug/L vs 0.05 ug/L for As and 1.6 ug/L vs. 0.02 ug/L)

- Arsenic in IHSS 201 groundwater (3.8 ug/L vs 0.05 ug/L)
- Uranium-233/234 in IHSS 200 groundwater (4.6 vs. 2.98 pCi/L)

Beryllium was not detected (zero detections out of 8 samples) in IHSS 201 groundwater.

The results of the PRG screen for sediment, surface water, and groundwater are included in Appendix E of TM 4.

8.0 WEIGHT-OF-EVIDENCE EVALUATION

8.1 Introduction

Gilbert (1993) recommends the use of professional judgement to "provide supporting evidence for accepting or rejecting the results of the screening and statistical tests. The basic question is: Do the results of the statistical tests make sense in light of what is known about the geology, hydrology, and geochemistry of the OU?" Gilbert considers whether the underlying assumptions for performing the statistical tests are valid. Because some of the underlying assumptions were not met and the results of the tests were considered inconclusive (see Subection 2.1), the Gilbert process was not performed for sediment, surface water, and groundwater. In order to assess whether the OU 3 concentration data was significantly different from background an alternative approach for comparing site to background data was used for sediment, surface water, and groundwater. The alternative approach is referred to as the "weight-of-evidence evaluation" because it relies on a series of data evaluation steps and involves the use of professional scientific judgement. The WOE evaluation involves the application of a variety of data analysis techniques in lieu of a rigorous, quantitative statistical testing scheme. These techniques correspond with the EPA-accepted professional judgement analytical techniques (ie., spatial analysis, temporal analysis, and pattern recognition). The use of the WOE Evaluation for groundwater, surface water (streams and reservoir), and sediment (streams and reservoir) data and the reasons why the application of the statisticals was not appropriate were discussed at the May 3, 1994 meeting with EPA, CDPHE, and DOE (see Attachment 3). EPA and CDPHE committed to discuss the use of the WOE Evaluation approach for metals with their internal resources and provide input to DOE by May 10, 1994. No input from EPA or CPDHE was received. However, to meeting the IAG schedule commitments, the COC selection process proceeded without additional input.

Following the Gilbert process allows for application of professional judgement arguments after the performance of the statistical tests (see Figure 8-1). Because the results of the statistical tests

were implausible and inconclusive for sediment, surface water, and groundwater, only the professional judgement steps of the Gilbert process were used for those media. Regardless whether the WOE Evaluation was applied as the first step in the process or the last, the resulting COCs would be the same (see results of the CDPHE Conservative Screen for OU 3 where the WOE step was used first in selecting PCOCs). If applied first, arsenic and beryllium would be eliminated as PCOCs before the concentration-toxicity and PRG screens. If the WOE evaluation is applied last, these chemicals would be eliminated as PCOCs.

This section discusses in detail the WOE evaluation for the chemical concentration data for the following chemicals included as COCs in EPA's informal review comments memo (EPA, 1994a):

- Arsenic and beryllium in sediment
- Arsenic and beryllium in groundwater
- ^{233/234}U in groundwater

Much of this information is included in TM 4 (DOE, 1994) and also is discussed in the Response to Comments (Attachment 1). However, this document contains additional information that has been added to help clarify the WOE evaluation results.

8.2 Weight-of-evidence Evaluation Process

The weight-of-evidence evaluation is consistent with those professional judgement evaluations approved by EPA in their October 25, 1993 memorandum commenting on the Strawman (DOE, 1993; EPA, 1993) document of the Gilbert process. These professional judgement evaluations include:

- Spatial analysis combined with the evaluation of physical processes affecting deposition and the evaluation of contribution of various water sources to OU 3 reservoirs
- Temporal analysis of data to identify seasonal variations or sampling anomalies
- Pattern recognition

Additionally, to supplement the analyses above, several other evaluation steps were performed:

- Evaluation of data populations using probability plot analysis

- Comparisons of means, standard deviations, and ranges of OU 3 concentration data to concentration data from the Background Geochemical Characterization Report (BGCR) (DOE, 1993c)
- Comparisons of means, standard deviations, and ranges of OU 3 concentration data to benchmark concentration data. The benchmark data collection activities are described in Subsection 8.3.
- Comparison to the CDPHE Phase I Public Health Exposures Studies Material of Concern list. This comparison was not used to eliminate COCs and was performed after the identification of the COCs was complete. The purpose was solely to support the decision that had already been made.

Spatial Analyses

Spatial analyses were performed for analytes in OU 3 sediments by evaluating patterns of concentrations at discrete sample points in each IHSS. Analytes showing a distinct spatial orientation rather than being randomly distributed may be designated as potential sources or potential hot spots. The physical processes, for example, sedimentation near the inflow of a stream into a lake, affecting concentration distribution and the contribution of various water sources to OU 3 reservoirs are considered.

Temporal Analysis

The PCOC concentration data in sediment were also evaluated over time to discern any anomalous trend or pattern. Concentration levels sharply elevated at one point in time may indicate a historical release event contributing to concentrations above background. Sediment core profiles (Figure 8-5) were analyzed for some analytes to evaluate if possible patterns existed throughout the sediment layer. Analyte profiles with discernible peaks may indicate source discharges from the RFETS or other sources of contamination.

Probability Plot Analysis

A software package, PROBLOT, was used to assess populations within the OU 3 data sets (see Appendix A). PROBLOT is conventionally used in the minerals exploration industry to guide investigators seeking anomalous mineral deposits (i.e., significantly above background) for extraction (Sinclair, 1986; Sinclair, 1976; Stanley, 1987). Concentration data (detects only) for

those chemicals with sufficient data (15 samples above detection limits for a given analyte and IHSS) were lognormally transformed and plotted on a cumulative frequency graph. Based on the cumulative frequency distribution, the number of populations for a given data set were identified. If one population was identified, it was inferred to represent a background population based on the comparison to background and benchmark data and the physicochemical processes occurring in the reservoirs. If two populations existed, it is possible that the higher population is the result of contamination. With two populations having low concentrations and concentrations that do not vary significantly between each other, however, the two populations may be explained by natural physical processes and not necessarily contamination.

Comparison of OU 3 Data to Benchmark Data

The three steps described above (spatial, temporal, and probability plot analyses) all indicate that concentrations of arsenic in OU 3 surface sediments are representative of naturally occurring conditions rather than contamination. To confirm this conclusion, concentrations of arsenic in surface sediments for each of the three IHSSs were compared to available background and literature benchmark data. This final step in the weight-of-evidence approach involves comparing the OU 3 data to background and benchmark data in a less formal, quantitative manner than using the five statistical tests included in the Gilbert methodology. However, it is important to remember, this step alone cannot eliminate arsenic as a COC. The benchmark data comparison in conjunction with the other weight-of-evidence evaluations provides the rationale that arsenic is not a COC.

The results of the evaluation steps were considered together to assess if a chemical was retained as a COC - the results of one evaluation step did not, by itself, characterize a chemical as a COC or eliminate a chemicals as a COC. Applying multiple evaluation steps is similar to the reasons for Gilbert's recommendation of using a family of statistical tools because no one statistical test exists that can adequately address the various types of data characteristics (Gilbert, 1993). To eliminate chemicals as COCs by this step, convincing evidence was needed to support the conclusion that detected levels of the chemical in OU 3 are representative of background conditions. If convincing evidence were not provided, the chemical is retained as a COC.

8.3 Benchmark Data Collection Activities

A search was performed to gather benchmark literature data for the comparison of OU 3 sediment and surface-water data. More than 20 sources were contacted to obtain benchmark data for sediments and surface water, as shown in Table 8-1.

The term "benchmark data" is used in TM 4 to represent the data compiled from literature and other data sources referenced in Table 8-1 to represent background conditions within the Front Range and Colorado. The data-gathering effort focused on obtaining reservoir and lake data in the Front Range and Colorado.

Benchmark data differ from background data sets, which are appropriate for statistical comparison. The term "background data" is used to represent the data collected and summarized in the Background Geochemical Characterization Report (DOE, 1993c) and the Rock Creek surface soil data. Data from the Background Geochemical Characterization Report were used to make comparisons to OU 3 data in the weight-of-evidence evaluation. The Rock Creek soil data were used in the statistical comparison tests.

The benchmark data that were primarily used for sediment comparisons include four lakes in the Rocky Mountain National Park: Lake Husted, Lake Louise, Lake Haiyaha, and the Loch (Heit, et al., 1984). Based on a professional judgement assessment, these lakes were not likely influenced by man-made sources of contamination. Sediment data were also available from Cherry Creek Reservoir (DRCOG, 1994). In addition, background sediment stream data from the Lowry Landfill Superfund site were also used (EPA, 1992).

During the benchmark data-collection activities, information was also collected from lakes outside of Colorado for comparative purposes. The results of this information can be used to support the comparison to background and Colorado benchmark data. For example, in some cases the OU 3 COC data is within the range of the background data, the Colorado benchmark data, and the out-of-state benchmark data--there are no anomalous values.

Data from Superfund sites and other impacted areas were also collected. The purpose of using information from contaminated sites is to place the OU 3 concentration/activity levels in perspective with other investigated sites. Contamination at these sites tend to be greater by a factor of 5, 10, or 100 or more times background concentrations. As an example, the maximum arsenic concentration in surface sediment is 17.7 mg/kg compared to a maximum BGCR background value of 17.3 mg/kg, while the Warm Springs Pond Superfund site is 1900 mg/kg. Contamination is not subtle, however, as shown in this example, the difference between the maximum OU 3 surface sediment concentration and the maximum background stream sediment concentration is subtle.

8.4 Arsenic in Sediment

This subsection presents the results of the weight-of-evidence evaluation applied to arsenic measured in OU 3 surface sediments. A summary of the analytical results for arsenic in the OU 3 sediments (for each IHSS) is presented in Table 8-2. Table 8-2 shows the summary statistics (before the COC selection was performed) by IHSS, including number of detects, number of samples, frequency of detection, minimum nondetected value, maximum nondetected value, minimum detected value, maximum detected value, arithmetic mean, standard deviation, normal 95 percent upper confidence limit (UCL), and lognormal 95 UCL. The summary statistics are used to provide the analyst the makeup of the data set (i.e., the frequency of detection and magnitude of concentration) before the COC selection process is performed. The use of summary statistics is part of an exploratory analysis phase that involved using visual and graphical presentations of the data.

8.4.1 Spatial Analysis

Arsenic concentrations were plotted at every sediment sample location in each IHSS (see Figures 8-2, 8-3, and 8-4). The maps show that the arsenic concentrations tend to be slightly higher in the samples collected in the middle of the reservoir than along the exposed shoreline and stream sediment samples. However, along the shoreline, in the streams, and in the middle areas of the reservoirs the arsenic levels are apparently randomly distributed - suggesting a natural population.

Natural limnological phenomena explain the slightly elevated concentrations in the center of the reservoirs. The finer particles of sediment tend to have the highest concentrations of organic matter and thus higher arsenic concentrations (Davis and Kent, 1990). These finer-sediment particles in the water column also tend to deposit in the center of the lake where flow velocities can no longer support particle suspension. The metals in OU 3 tend to exhibit this natural concentration distribution of higher concentrations in the center of the lake (Table 8-3). The shoreline sediments are exposed most of the year and the finer-grained particles are preferentially removed by wind and water erosion (ie., resulting in lower concentrations).

Since Mower Reservoir (IHSS 202) receives 100 percent of its water input from the Rocky Flats Plant drainage area, and Great Western Reservoir (IHSS 201) and Standley Lake (IHSS 202) receive 65 percent to more than 90 percent, respectively, of water input from Clear Creek (ASI, 1990) one might expect significantly higher concentrations in Mower Reservoir if RFETS-related contamination were present. However, the arsenic concentrations in Mower Reservoir sediment are

not significantly greater than Great Western Reservoir or Standley Lake (based on the results of statistical tests, Standley Lake is significantly higher than Mower Reservoir for the sediments in the middle of the reservoir and Great Western Reservoir and Mower Reservoir are not significantly different; there is no difference in the nearshore sediments arsenic concentrations between any of the reservoirs); this suggests that arsenic originates from background sources and was deposited in the IHSS reservoirs by natural processes.

Mower Reservoir also has less area/volume to dilute concentrations compared to Standley Lake yet the concentrations in Standley Lake are higher (realizing Standley lake receives 90% of its water from Clear Creek and Mower receives 100% from the Rocky Flats drainage).

8.4.2 Temporal Analysis

The arsenic concentration data in sediment were also evaluated over time to discern any anomalous trend or pattern. Arsenic concentrations in sediment core profiles did not show any consistent peaks or patterns (see Figure 8-5). The concentrations of arsenic in the sediment core samples range from 3.6 mg/kg to 36.2 mg/kg. Table 8-4 list the minimum, mean, and maximum concentration and the depth for core samples.

Sedimentation rates estimated for the reservoirs are as follows: 0.7 to 0.8 inches per year (in/yr) for IHSS 201; 0.9 in/yr for IHSS 200; 0.3 in/yr for IHSS 202.

Figure 8-6 compares arsenic concentrations in a sediment core to plutonium and other selected analytes. While $^{239/240}\text{Pu}$ exhibits a distinct peak suggesting deposition of contamination associated with a specific time period, arsenic and the other analytes do not show such peaks.

8.4.3 Probability Plot Analysis

According to the geochemical analysis using PROBPLOT, only one population is seen for arsenic in each of the three reservoirs (see Figures 8-7, 8-8, and 8-9). Figure 8-7 shows the PROBPLOT output for arsenic in Great Western Reservoir (IHSS 200). Because of low concentrations (comparable to benchmark data) and the lack of separate populations, arsenic in OU 3 samples is identified as falling within the background population. Although Standley Lake (IHSS 201) has a maximum that is almost twice that of Great Western Reservoir (IHSS 200) and Mower Reservoir (IHSS 202), the means are essentially equal and fall within benchmark data.

8.4.4 Comparison of OU 3 Data to Benchmark Data

This evaluation step for arsenic involved the use of a visual data-presentation technique (Figure 8-10) where the magnitude of concentrations of the OU 3 data for streams and reservoir sediment are presented with the Rocky Flats background data for stream sediments and relevant benchmark data from the literature. The top portion of Figure 8-10 is a tabulation of these data; the bottom segment profiles the data to promote comparison of individual data points as well as ranges. The data presented in Figure 8-10 include sediment data from Rocky Mountain National Park lakes, the Great Lakes, Adirondack lakes, Cherry Creek Reservoir in Colorado, Missoula Lake bed sediments, worldwide data, and data from Superfund sites. The purpose of using information from contaminated sites (the Warm Springs Pond Superfund site and the Clear Creek Superfund site), in addition to nonimpacted sites, is to place OU 3 levels in perspective with other investigated sites.

Figure 8-10 illustrates the following:

- The arsenic concentrations for OU 3 sediments between the IHSSs are consistent (the means 5.3, 4.9, 4.8, 7.0, 4.9, and 5.2 mg/kg are very consistent). All reported concentrations are less than 17.7 milligrams per kilogram (mg/kg) and there are no apparent spurious data that would suggest anomalous concentrations.
- The Rocky Mountain National Park arsenic concentration means range from 1.4 to 8.4 mg/kg compared to a range of OU 3 means, 4.9 to 7.0 mg/kg.
- The OU 3 mean concentrations are bounded by the lake data (2 to 5 mg/kg, 5 to 7 mg/kg, mean of 6.6 mg/kg and maximum of 9.2 mg/kg for the Great Lakes, Adirondack lake, and Lake Michigan, respectively).
- The Cherry Creek reservoir mean concentration, 5.57 mg/kg, is slightly higher the mean values for the OU 3 reservoirs and creeks.
- The range of OU 3 arsenic concentrations in reservoirs (1.2 to 17.7 mg/kg) is comparable with the ranges of the BGCR (DOE, 1993c) data (sediments that are not impacted)–0.39 to 17.3 mg/kg. Additionally, the OU 3 and background data are within the range, and comparable to, the expected worldwide ranges (0.1 to 55 mg/kg, mean of 7.2 mg/kg [Dragun, 1988]).
- The profile of the OU 3 mean concentrations of arsenic in OU 3 sediments (4.76 to 6.96 mg/kg; range of 1.2 to 17.7 mg/kg) shows concentrations comparable to

ranges of Lowry Landfill Superfund site stream sediments that are assumed not to be impacted (0.9 to 17 mg/kg) and a mean concentration of 5.0 mg/kg.

- Both the OU 3 data and the benchmark data are distinguishable from the data representing arsenic contamination (e.g., Warm Springs Pond, and Clear Creek). Arsenic concentrations in OU 3 are not within the upper end of the ranges of heavily polluted sites (Warm Springs Pond and Clear Creek). The maximum arsenic concentration in OU 3 sediments ranges from 6.8 mg/kg to 17.7 mg/kg, compared with 46 mg/kg at the Clear Creek Superfund site (CDPHE, 1990) and 1,910 mg/kg at the Warm Springs Pond Superfund site (EPA, 1988).
- All data (OU 3, background, and benchmark data) are greater than the 10^{-6} PRG (based on residential exposure) of 0.37 mg/kg.

8.4.5 Conclusions from the Weight-of-Evidence Evaluation

Based on the full weight of the evidence presented in this section--the lack of discernible spatial or temporal trends, the results of the probability plot analysis, the similarity of the OU 3 arsenic concentrations to background and benchmark arsenic concentrations--arsenic has been eliminated as a COC in surface sediment for the three IHSSs.

8.5 Beryllium In Sediment

A summary of the analytical results for beryllium in sediments (surface and subsurface sediments for IHSS 200 and surface sediments only for IHSSs 201 and 202) is presented in Table 8-2.

8.5.1 Spatial Analysis

Beryllium concentrations were plotted at every sediment sample location in each IHSS on maps generated by GIS (Figures 8-2, 8-3, and 8-4). Beryllium exhibited narrow ranges of concentrations in all three IHSSs (i.e., difference between minimum and maximum detected values was less than 1.5 mg/kg for all IHSSs). The concentrations range from 0.24 to 1.60 mg/kg in IHSS 200, 0.15 to 1.60 mg/kg in IHSS 201, and 0.41 to 1.50 mg/kg for IHSS 202. The maps show that, in general, the samples associated with the upper end of the concentrations ranges tend to be those collected in the middle of the reservoir. However, along the shoreline, in the streams, and in the middle areas of the reservoirs the beryllium levels are apparently randomly distributed. There is no

discernible pattern of beryllium concentration in sediments, thus suggesting a natural, randomly distributed population.

Natural limnological phenomena explain the slightly elevated concentrations in the center of the reservoirs. The finer particles of sediment tend to have the highest concentrations of organic matter and thus higher beryllium concentrations (Davis and Kent, 1990). The metals in OU 3 tend to exhibit this natural concentration distribution. The shoreline sediments are exposed most of the year and the finer-grained particles are preferentially removed by wind and water erosion. These finer-sediment particles in the water column also tend to deposit in the center of the lake where flow velocities can no longer support particle suspension.

8.5.2 Temporal Analysis

Beryllium concentrations in sediment core profiles from IHSSs 200 through 202 do not show any consistent peaks or patterns (Figure 8-11 shows selected core profiles for the three IHSSs). The core data include maximum depths of 28 inches, 34 inches, and 20 inches for IHSSs 200, 201, and 202, respectively. These depths correspond to the year 1965, or earlier. As noted for the surface sediments, beryllium also exhibits narrow ranges of concentrations in subsurface sediments for the three IHSSs (i.e., difference between minimum and maximum detected concentrations are 1.8 mg/kg, 1.3 mg/kg, and 0.9 mg/kg for IHSS 200, 201, and 202, respectively). The concentrations of beryllium in the subsurface sediment core samples range from 0.53 to 2.30 mg/kg for IHSS 200, 0.34 to 1.60 mg/kg for IHSS 201, and 0.64 to 1.54 mg/kg for IHSS 202.

8.5.3 Probability Plot Analysis

According to the geochemical analysis using PROBPLOT, only one population is seen for beryllium in surface sediments for each of the three reservoirs. Figures included in Appendix A show PROBPLOT outputs for beryllium in IHSS 200, 201, and 202. Because of overall low concentrations (maximum value of 1.60 mg/kg detected in IHSS 200 and 201; maximum value of 1.5 mg/kg in IHSS 202) which are similar or below background and benchmark concentrations (see Section 8.5.4), and the lack of separate populations, beryllium in OU 3 samples is identified as falling within the background population.

8.5.4 Comparison of OU 3 Data to Benchmark Data

The three steps described above (spatial, temporal, and probability plot analyses) all indicate that concentrations of beryllium in OU 3 surface sediments are representative of naturally occurring

conditions rather than contamination from RFETS. To confirm this conclusion, concentrations of beryllium in OU 3 surface sediments were compared to available background and literature benchmark data. This final step in the weight-of-evidence approach involves comparing the OU 3 data to background and benchmark data in a less formal, quantitative manner than using the five statistical tests included in the Gilbert methodology. However, this step alone cannot eliminate beryllium as a COC. The benchmark data comparison in conjunction with the other weight-of-evidence evaluations provides the rationale that beryllium is not a COC.

This evaluation step for beryllium involved the use of a visual data-presentation technique (Figure 8-12) where the magnitude of concentrations of the OU 3 data for streams and reservoir sediment are presented with the BGCR and Lowry Landfill Superfund Site background data for stream sediments, and relevant benchmark data from the literature. The top portion of Figure 8-12 is a tabulation of these data; the bottom segment profiles the data to promote comparison of individual data points as well as ranges. The benchmark data presented in Figure 8-12 include sediment data from Rocky Mountain National Park lakes and Cherry Creek Reservoir in Colorado. In addition, the risk-based PRG for beryllium is presented.

Figure 8-12 illustrates the following:

- The beryllium concentrations for OU 3 surface sediments are consistent between the IHSSs. All reported concentrations are less than or equal to 1.6 milligrams per kilogram (mg/kg) and there are no apparent spurious data that would suggest anomalous concentrations.
- The range of OU 3 beryllium concentrations in reservoir surface sediments (0.15 to 1.6 mg/kg) is comparable to the range of beryllium in the BGCR (DOE, 1993c) data (i.e., stream sediments that are not impacted by activities at RFETS)–0.15 to 1.3 mg/kg (standard deviation of 1.69).
- The range of concentrations of beryllium in OU 3 surface sediments (0.15 to 1.6 mg/kg) shows concentrations comparable to ranges of stream sediment data from samples collected to represent background conditions for the Lowry Landfill Superfund Site that are assumed not to be impacted by contamination (0.23 to 2.0 mg/kg).
- Mean concentrations of beryllium in reservoir samples from the three IHSSs (0.85, 0.70 and 1.06 mg/kg for IHSSs 200, 201, and 202, respectively) are all lower than

mean concentrations in Rocky Mountain National Park lake samples (3.9, 5.0, 9.3, and 7.4 mg/kg for Lake Husted, Lake Louise, Lake Haiyaha, and The Loch, respectively) and Cherry Creek Reservoir (4.03 mg/kg).

- Minimum values for the BGCR and Lowry background data (0.15 and 0.23 mg/kg, respectively) are equal to or exceed the PRG for beryllium (0.15 mg/kg), mean values for the Rocky Mountain National Park lakes all exceed the PRG.

8.5.5 Conclusions from the Weight-of-Evidence Evaluation

Based on the full weight of the evidence presented in this section, the similarity of the OU 3 mean concentrations to background and benchmark, the probability plot analysis, and the lack of discernible spatial trends, beryllium has been eliminated as a COC in surface sediment for the three IHSSs.

8.6 Americium-241 In Sediment

Americium-241 in sediment does not exceed the 10^{-6} PRG based on residential exposure in the surface and subsurface sediments in all three IHSSs and, therefore, was eliminated as a COC.

8.7 Arsenic In Groundwater

Two groundwater wells were installed during the OU 3 field investigation: one immediately downstream of Great Western Reservoir (IHSS 200, Well 49192) and one immediately downstream of Standley Lake (IHSS 201, Well 49292). The wells were installed to evaluate the potential for contaminants to migrate from the surface-water bodies to shallow groundwater (DOE, 1992).

The analytes remaining after the PRG screen were assessed by using the weight-of-evidence evaluation approach to determine if any analytes were consistently detected above background and therefore should be considered as COCs. The approach for evaluating these chemicals in groundwater included the following:

- Comparison of OU 3 data to background groundwater data for both upper and lower hydrostratigraphic units (UHSU and LHSU, respectively) at the RFETS, and literature benchmark data (comparison of means and ranges of concentrations)
- Temporal analysis of anomalies in the OU 3 data

- Evaluation of measurement uncertainty
- Geochemical evaluations of hydrologic setting

Concentrations of analytes that exceed the PRGs were compared to the background data presented in the Background Geochemical Characterization Report (DOE, 1993c). Analytes for which the OU 3 mean and range were less than the comparative background groundwater data were eliminated as COCs. The background groundwater monitoring wells were selected to be representative of the upper hydrostratigraphic unit (UHSU) (Rocky Flats alluvium, the colluvium, valley fill alluvium, weathered claystone); and the lower hydrostratigraphic unit (LHSU) (the unweathered Arapahoe and Laramie formation bedrock).

A Piper diagram showing major-ion chemistry for the OU 3 groundwater wells and background UHSU and LHSU is presented in Figure 8-13. The concentrations of major anions (as meq/L [milliequivalents per liter]) are given as percentages of the total milliequivalents per liter. According to Figure 8-13, Well 49192 (IHSS 200) has a water chemistry similar to the UHSU, whereas Well 49292 (IHSS 201) has a water chemistry more similar to the LHSU.

A number of reasons exist for spatial changes and differences in groundwater chemistry. Some changes may be due to the natural evolution of groundwater chemistry along a flow path, such as an increase in TDS content in the downgradient direction. Other changes in water chemistry may be the result of ion-exchange processes, oxidation/reduction reactions, or mineral precipitation/dissolution processes. However, the similarity of the water typing for the OU 3 wells compared to the background data groupings indicates that the BGCR provides a suitable data set for determining if the OU 3 data are consistently above background, in conjunction with the temporal, analytical uncertainty, and geochemical evaluations.

Summary statistics for arsenic, beryllium, and $^{233/234}\text{U}$ in groundwater are presented in Table 8-5. Also included in Table 8-5 are the minimum, maximum, arithmetic mean, standard deviation, and mean plus two standard deviations for the background data. Based on the water typing information (Figure 8-13), data for Well 49192 (IHSS 200) have been compared to the background data for the UHSU, and data for Well 49292 (IHSS 201) have been compared to the background data for the LHSU. Benchmark values presented by Dragun (1988) for those chemicals with available data have also been included in Table 8-5.

The measurement uncertainty has been considered in determining if the OU 3 groundwater results significantly exceed background. "Under optimum conditions, the analytical results for major

analytes in groundwater have an accuracy of ± 2 to ± 10 percent. That is, the difference between the reported result and the actual concentration in the sample at the time of analysis should be between 2 and 10 percent of the actual value" (Hem, 1985). Analytes present in concentrations above 100 mg/L generally can be determined with an accuracy of better than ± 5 percent. The limits of precision (reproducibility) are similar. For analytes present in concentrations below 1 mg/L, the accuracy is generally not better than ± 10 percent and can be poorer (Hem, 1985). Except for the major anions and cations, most of the analytes for OU 3 are present in concentrations less than 1 mg/L. Therefore, the analytical accuracy can be estimated to be ± 10 percent. To address analytical uncertainty as well as sampling uncertainty, the OU 3 mean has also been compared to the value of the background mean plus two standard deviations.

Arsenic was eliminated as a groundwater COC for IHSS 201 based on the following (see Table 8-5 and Figure 8-14):

- The mean concentration of total arsenic in IHSS 201 (2.5 $\mu\text{g/L}$) is less than the mean concentration of total arsenic in the LHSU (2.76 $\mu\text{g/L}$).
- The range of concentrations of total arsenic in IHSS 201 (2.7 to 3.8 $\mu\text{g/L}$) is less than the range of concentrations for the LHSU (0.35 to 7 $\mu\text{g/L}$).
- The maximum value of total arsenic in IHSS 201 (3.8 $\mu\text{g/L}$) is below the maximum benchmark value (30 $\mu\text{g/L}$).

A comparison of IHSS 200 arsenic groundwater data to background and benchmark data indicates the following (see Table 8-5 and Figure 8-14):

- The mean (2.99 $\mu\text{g/L}$) for total arsenic is greater than that for the background UHSU (1.95 $\mu\text{g/L}$). However, the mean (2.99 $\mu\text{g/L}$) is within two standard deviations of the background mean (mean + 2 standard deviations = 5.37 $\mu\text{g/L}$).
- The maximum total arsenic value detected in Well 49192 (6.9 $\mu\text{g/L}$) is similar to the maximum detected in the UHSU background data (5 $\mu\text{g/L}$).
- The maximum value for total arsenic (6.9 $\mu\text{g/L}$) is less than the maximum value found in literature for groundwater (30 $\mu\text{g/L}$ [Dragun, 1988]).

Because arsenic is present in Well 49192 (IHSS 200) at concentrations that are similar to, but not below the background mean and maximum, arsenic has been evaluated further using temporal variability, analytical uncertainty, and geochemical analyses to determine if it should be retained on the COC list for IHSS 200 groundwater.

In reviewing the data from Well 49192, one anomaly was noted: three of the eight sample rounds had elevated amounts of total suspended solids (TSS). On January 29, 1993, April 29, 1993, and November 18, 1993, TSS were 840, 1300, and 948 mg/L, respectively. On the five other sample dates, the TSS were all less than 160 mg/L. The elevated amount of TSS, in conjunction with elevated total aluminum and total iron (over one order of magnitude greater than the other five sampling rounds), indicates that the sampling technique on those days may be suspect (see Figure 8-15). The correlation coefficients between TSS and aluminum and TSS and iron are 0.99 and 0.96, respectively. A review of the background TSS data for both the UHSU and the LHSU shows a small percentage (less than 10 percent) of TSS values greater than 500 mg/L. It is possible that when the sampling bailer was lowered in the well, the bailer may have hit the bottom of the well and dislodged sediments into the water column. Other total metal analyses are also higher during these three sample events.

The three greatest detections (6.9 µg/L, 5.2 µg/L, and 3.5 µg/L) of arsenic correlate with the three sampling events exhibiting elevated TSS (Figure 8-15). When the arithmetic mean for the well OU 3 data is recalculated, excluding the data from these three sampling events, the OU 3 mean (1.67 µg/L, recalculated) is less than the UHSU background mean (as seen in Figure 8-14).

Based on the similarity of the OU 3 and the UHSU background means (less than two standard deviations of the background mean), the OU 3 mean being less than the LHSU background mean, the analytical and sampling uncertainty, and the potential for sampling error (three rounds with high values of TSS), arsenic concentrations in OU 3 groundwater were determined to be not above background; therefore, arsenic has been eliminated as a COC in OU 3 groundwater. This conclusion is supported by the Phase I Health Studies, which did not identify arsenic as a material of concern (CDPHE, 1991b).

8.8 Beryllium in Groundwater

Beryllium was eliminated as a COC based on a comparison of detected values to BGCR groundwater data (DOE, 1993c). Table 8-5 summarizes the OU 3 analytical results for beryllium in groundwater (IHSS 200 and 201; monitoring wells were not installed in IHSS 202) and the BGCR

analytical results for groundwater. In addition, literature benchmark data for groundwater is included on Table 8-5.

Table 8-5 indicates the following:

- Beryllium was not detected in any of the 8 samples from IHSS 201 analyzed for total metals or the 8 samples from IHSS 201 analyzed for dissolved metals; the detection limits for these samples was 1 µg/L; the contract required reporting limit for beryllium in water samples is 5 µg/L.
- The mean concentration of total beryllium for IHSS 200 (0.91 µg/L) is essentially equal to the mean concentrations of the UHSU (1.07 µg/L).
- The range of concentrations detected in total beryllium samples for IHSS 200 (1.1 to 1.6 µg/L) is within the range of concentrations for the UHSU (0.4 to 4.8 µg/L); beryllium was not detected in any of the samples from IHSS 200 analyzed for dissolved metals (detection limit of 1 µg/L).
- The maximum detected value of beryllium in IHSS 200 (1.6 µg/L) is approximately one order of magnitude less than the maximum benchmark value (10 µg/L).
- The minimum values of beryllium detected in the UHSU and LHSU exceed the risk-based PRG (0.0198 µg/L).

Based on the comparison of OU 3 data to background and benchmark data, beryllium was eliminated as a groundwater COC in IHSS 200 and 201.

8.9 Uranium-233/234 in Groundwater

Uranium-233/234 was eliminated as a COC based on a comparison of detected values to BGCR groundwater data (DOE, 1993c). Table 8-5 summarizes the OU 3 analytical results for ^{233/234}U in groundwater (IHSS 200 and 201; monitoring wells were not installed in IHSS 202) and the BGCR analytical results for groundwater.

Table 8-5 indicates the following:

- The mean concentration of total $^{233/234}\text{U}$ for IHSS 200 (4.00 pCi/L) is less than the mean concentrations of the UHSU (15.62 pCi/L); the mean concentration of dissolved $^{233/234}\text{U}$ for IHSS 200 (2.75 pCi/L) is less than the mean concentration of the UHSU (6.23 pCi/L).
- The mean concentration of total $^{233/234}\text{U}$ for IHSS 201 (0.755 pCi/L) is less than the mean concentrations of the UHSU and LHSU (15.62 pCi/L and 0.77 pCi/L, respectively); the mean concentration of dissolved $^{233/234}\text{U}$ in IHSS 201 (0.694 pCi/L) is less than the mean concentrations of the UHSU and LHSU (6.23 pCi/L and 1.64 pCi/L, respectively).
- The range of concentrations detected in total $^{233/234}\text{U}$ samples for IHSS 200 (3.4 to 4.6 pCi/L) is within the range of concentrations for the UHSU (0.0 to 164 pCi/L); the range of concentrations detected in dissolved $^{233/234}\text{U}$ for IHSS 200 (0.26 to 4.84 pCi/L) is within the range of concentrations for the UHSU and LHSU (-0.02 to 199.5 pCi/L and -0.01 to 15.33 pCi/L, respectively).
- The range of concentrations detected in total $^{233/234}\text{U}$ samples for IHSS 201 (0.64 to 0.87 pCi/L) is within the range of concentrations for the UHSU and LHSU (0.0 to 164 pCi/L and 0.15 to 1.52 pCi/L, respectively); the range of concentrations detected in dissolved $^{233/234}\text{U}$ for IHSS 201 (0.31 to 1.2 pCi/L) is within the range of concentrations for the UHSU and LHSU (-0.02 to 199.5 pCi/L and -0.01 to 15.33 pCi/L, respectively).

Based on the comparison of OU 3 data to background data, $^{233/234}\text{U}$ was eliminated as a groundwater COC in IHSSs 200 and 201.

9.0 SUMMARY

Based on the results of the COC Selection Process applied to the OU 3 analytical data the following chemicals are COCs for OU 3:

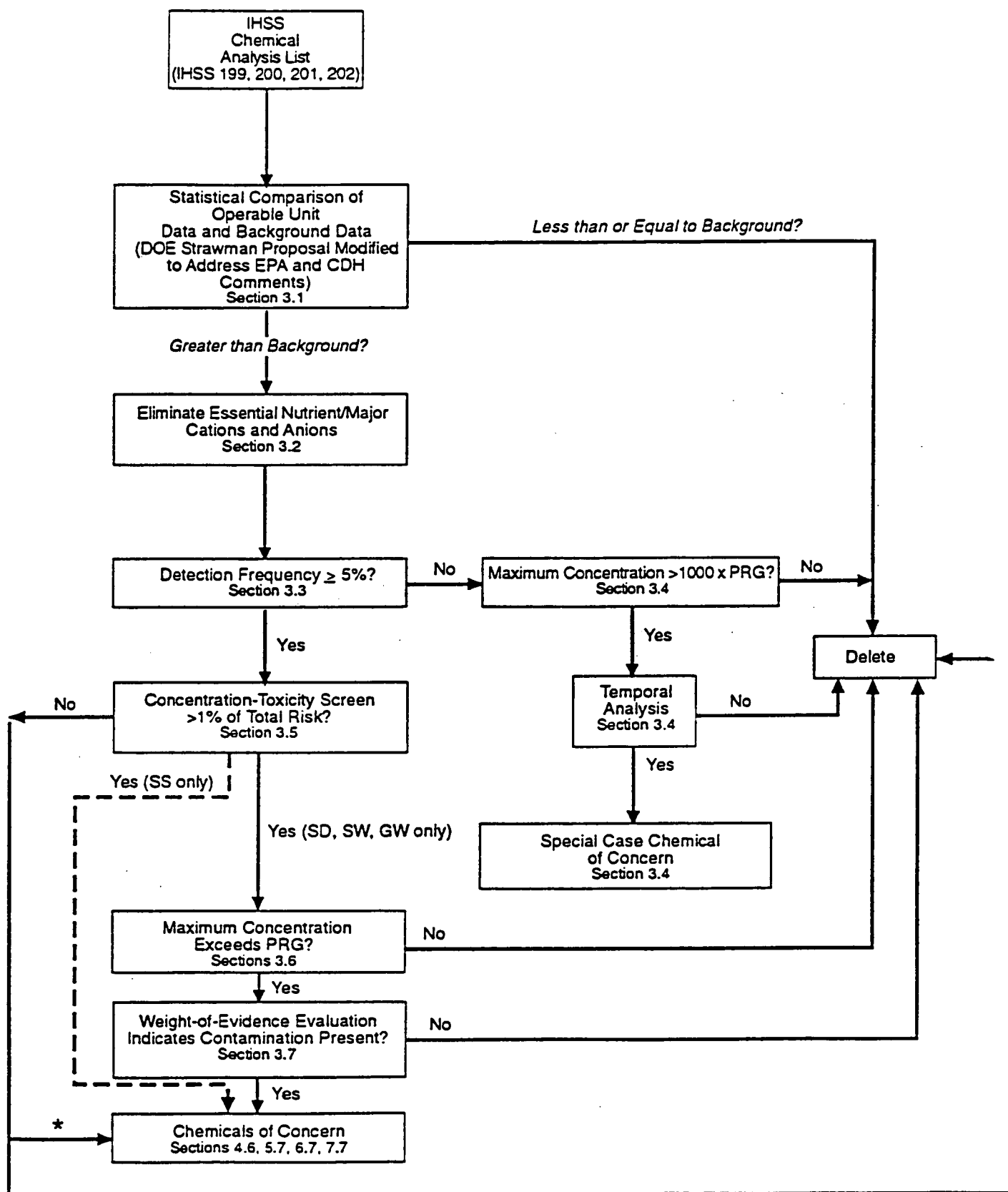
- $^{239/240}\text{Pu}$ and ^{241}Am in surface soil (IHSS 199)
- $^{239/240}\text{Pu}$ in Great Western Reservoir surface sediments (IHSS 200)

Additional information regarding chemicals not found on EPA's list of proposed COCs can be found in TM 4 (DOE, 1994).

10.0 REFERENCES

- CDPHE/EPA/DOE, 1994. Colorado Department of Public Health and Environment, United States Environmental Protection Agency, and United States Department of Energy. Presentation on the Conservative Screen Process for Identification of Source Areas and Data Aggregation for Calculation of Exposure Point Concentrations. June 3, 1994.
- CDPHE/EPA, 1993. Colorado Department of Public Health and Environment, United States Environmental Protection Agency. Background Comparisons approval letter from CDPHE and EPA. Resumption of Baseline Risk Assessment Work. Letter from Joan Sowinski (CDPHE) and Robert L. Duprey (EPA) to James K. Hartman (DOE). November 18, 1993.
- CDPHE, 1990. Colorado Department of Public Health and Environment. Clear Creek Phase II Remedial Investigation. Final Report. September 21, 1990.
- Davis and Kent, 1990. J.A. Davis and D.B. Kent. Surface Complexation Modeling in Aqueous Geochemistry. In: Mineral-Water Interface Geochemistry. M.G. Hochella and A.F. White, eds. Mineralogical Society of America, *Reviews in Mineralogy*, Volume 23, pp. 177-260. 1990.
- DOE, 1994a. United States Department of Energy. Technical Memorandum No. 4, Human Health Risk Assessment for Operable Unit 3, Rocky Flat Environmental Technology Site. Chemicals of Concern Identification. Environmental Restoration Program. Golden, Colorado. February 28, 1992.
- DOE, 1994b. United States Department of Energy. Rocky Flats Plant Site-wide Quality Assurance Project Plan for CERCLA Remedial Investigations/Feasibility Studies and RCRA Facility Investigations/Corrective Measures Studies Activities. January 5, 1994.
- DOE, 1993a. United States Department of Energy. Strawman of the statistical background comparison methods.
- DOE, 1993a. United States Department of Energy. Guidance for Conducting Statistical Comparison of RFI/RI Data and Background Data at the Rocky Flats Plant. Document No. 93-RF-14529, 11/30/93. November 30, 1993.
- DOE, 1993b. United States Department of Energy. Background Geochemical Characterization Report. September 30, 1993.
- DOE, 1992. United States Department of Energy. RFI/RI Work Plan for OU 3 Rocky Flats Plant. Environmental Restoration Program. (Manual 21100-WP-OU3.1, 2/28/92). Golden, Colorado. February 28, 1992.
- Dragun, 1988. James Dragun. The Soil Chemistry of Hazardous Materials. Hazardous Materials Control Research Institute. Silver Springs, MD. 1988
- EPA, 1995. United States Environmental Protection Agency. Review comments on TM 4. January 4, 1995.
- EPA, 1994. United States Environmental Protection Agency. Correspondence from Martin Hestmark (EPA) to Richard Schassburger (DOE) regarding Operable Unit 3 comparison to background. March 24, 1994.

- EPA, 1994. United States Environmental Protection Agency. Region VIII. Evaluating and Identifying Contaminants of Concern for Human Health. Document No. RA-03. September 1994.
- EPA, 1993. United States Environmental Protection Agency. EPA comments on the strawman of the statistical background comparison methods.
- EPA, 1989. United States Environmental Protection Agency. Risk Assessment Guidance for Superfund. Volume 1: Part A. Office of Emergency and Remedial Response. EPA/540/6-90/008. October, 1990.
- EPA, 1988. United States Environmental Protection Agency. Warm Springs Pond OU F Draft Remedial Investigation Report. 1988.
- EG&G, 1994. EG&G Rocky Flats, Inc. Methodology for Statistical Comparisons of Data to Background. EG&G Memorandum 94-RF-02971-SG-179-94. Golden, Colorado. March 14, 1994.
- Gilbert, 1993. Richard O. Gilbert. Recommended process for implementation by Rocky Flats Plant (RFP) to compare environmental restoration site analytical results obtained in operable units (OU) to background concentrations. July 30, 1993.
- Gilbert, 1987. Richard O. Gilbert. Statistical Methods for Environmental Pollution Monitoring. New York: Van Nostrand Reinhold Publishers. 1987.
- Heit, et al., 1985. Merrill Heit, Catherine Klusek, and Jill Baron. Evidence of Deposition of Anthropogenic Pollutants in Remote Rocky Mountain Lakes. *Water, Air and Soil Pollution* 22 (1984) 403-416. D. Reidel Publishing Company.
- IAG, 1991. Rocky Flat Interagency Agreement Between the State of Colorado, the Environmental Protection Agency, and the Department of Energy. January, 1991.
- Sinclair, 1986. A.J. Sinclair. Statistical Interpretation of Soil Geochemical Data in Exploration Geochemistry: Design and Interpretation of Soil Surveys. Society of Economic Geologists, El Paso TX, pp. 97-116. 1986.
- Stanley, 1987. C.R. Stanley. PROBPLOT: An Interactive Computer Program to Fit Mixtures of Normal (or Lognormal) Distributions with Maximum Likelihood Optimization Procedures. Association of Exploration Geochemists, Special Volume No. 14, 1987.



* Professional Judgement

SS = Surface Soil
SD = Sediments
SW = Surface Water
GW = Groundwater

Source: Adapted from: CDPHE/EPA, 1994

Figure 1-1
HUMAN HEALTH RISK ASSESSMENT
CHEMICALS OF CONCERN
SELECTION PROCESS

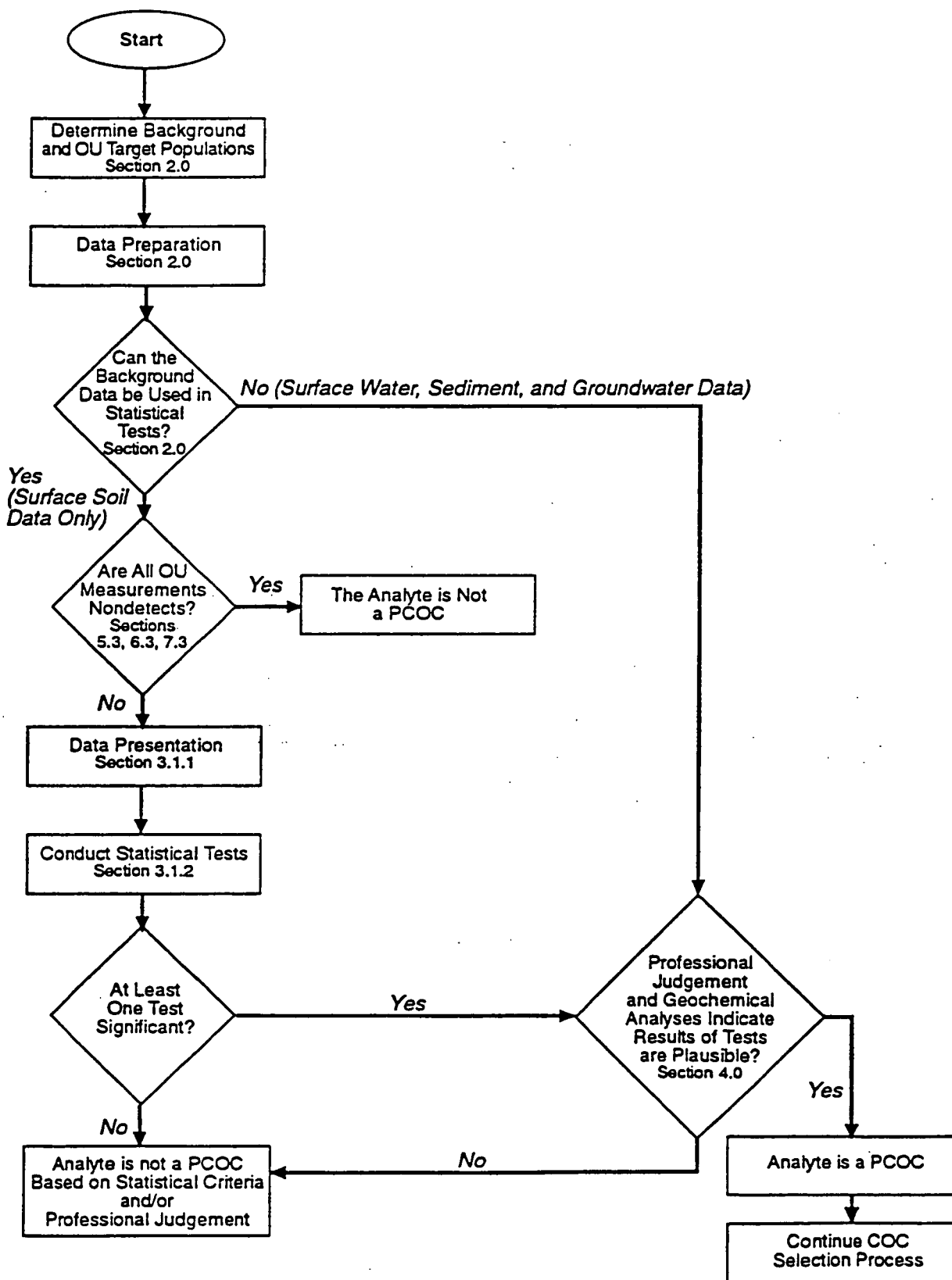


Figure 8-1
FLOWCHART FOR COMPARING OU
DATA TO BACKGROUND

Figure 8-5 Sediment Core Plots- Arsenic

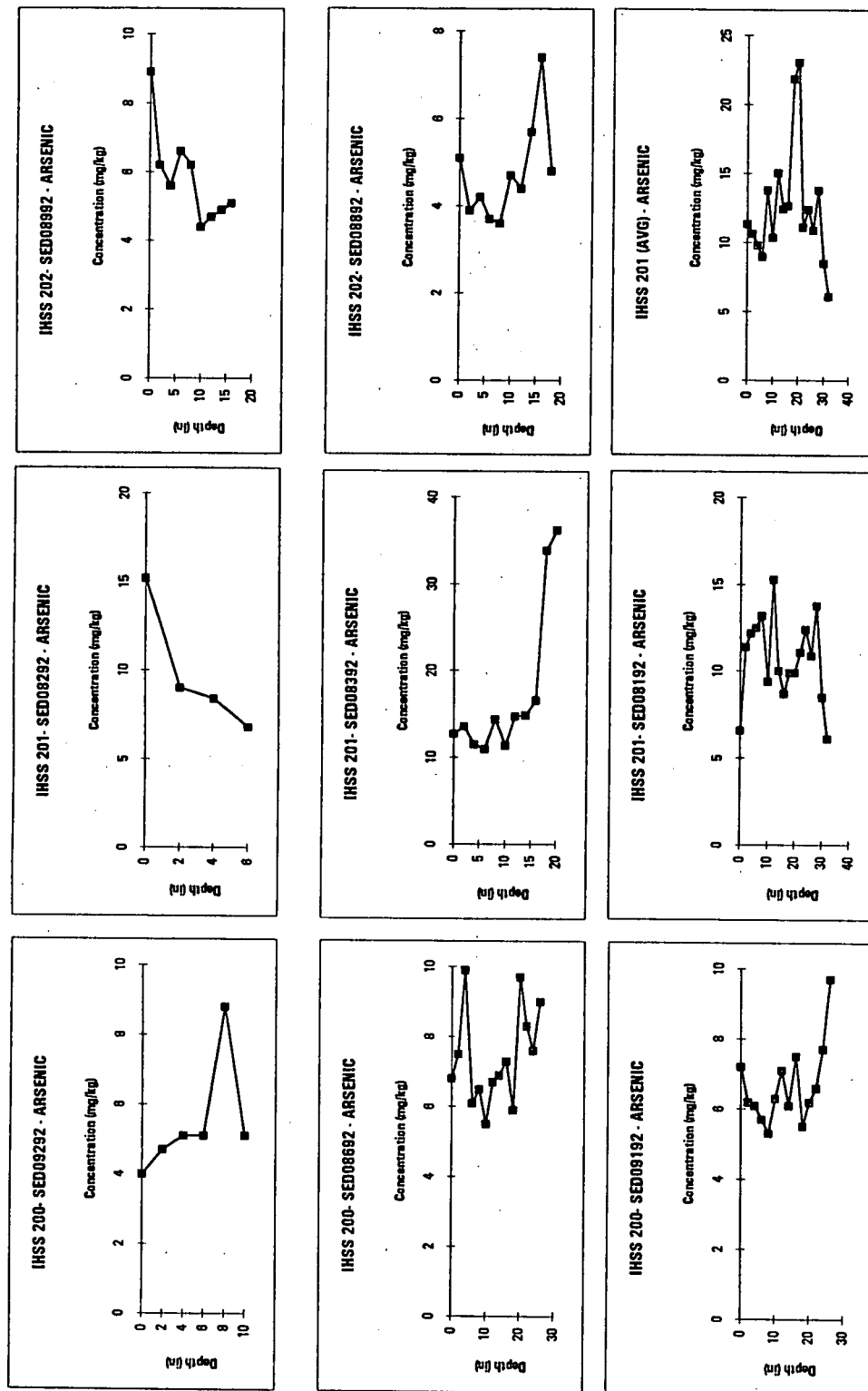


Figure 8-6a Sediment Core Plots

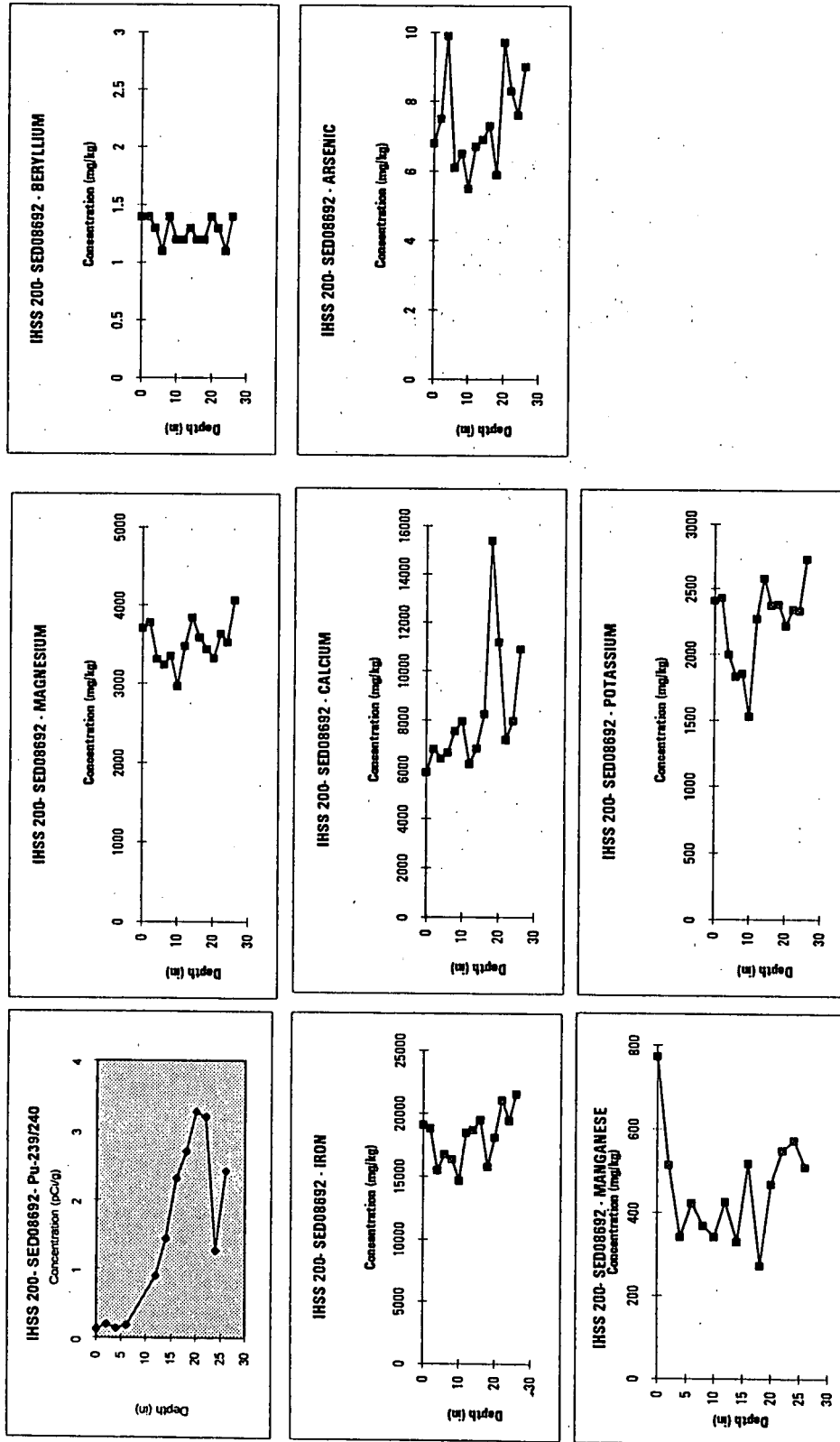


Figure 8-8b Sediment Core Plots

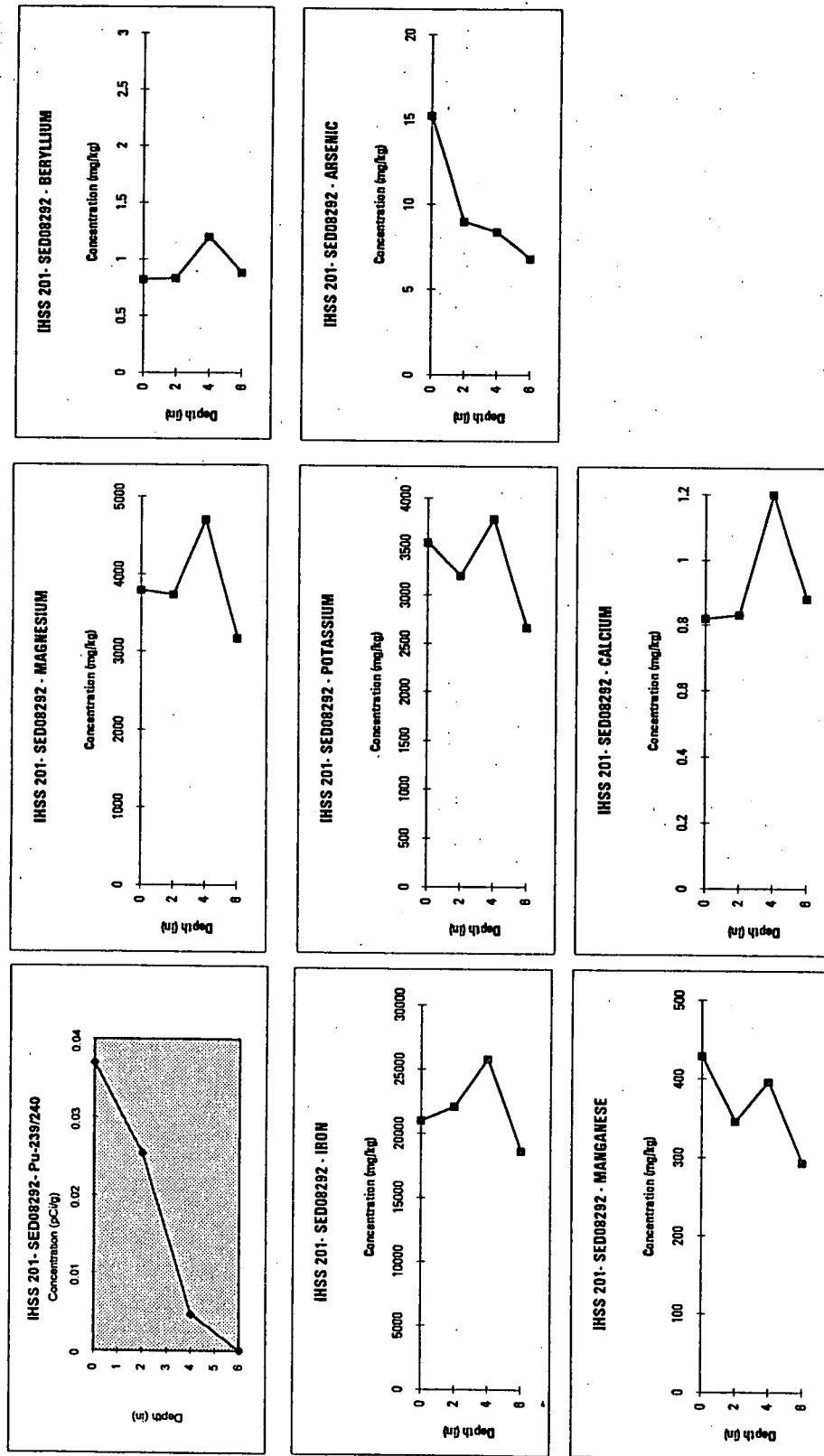
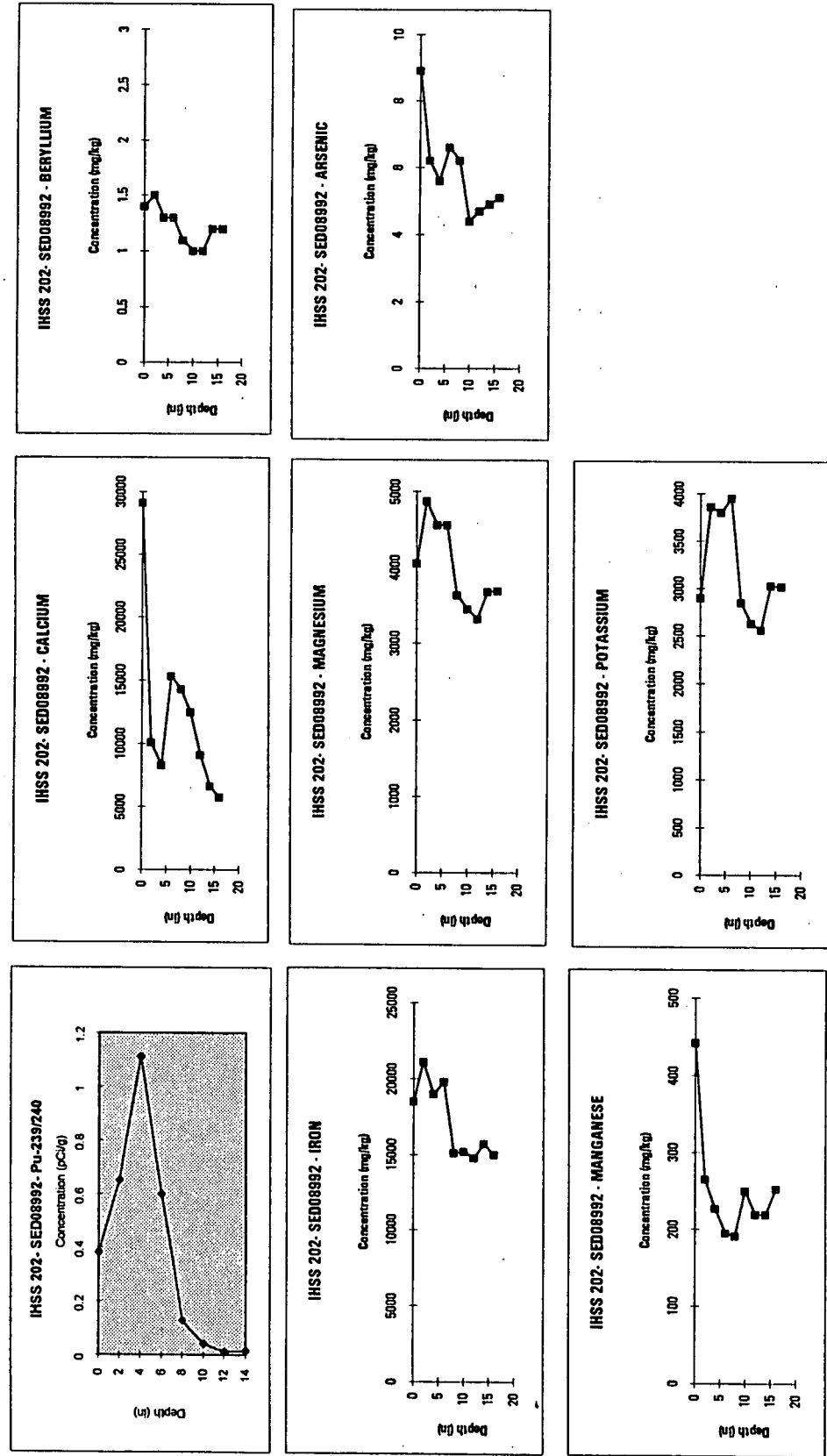


Figure 8-6e Sediment Core Plots



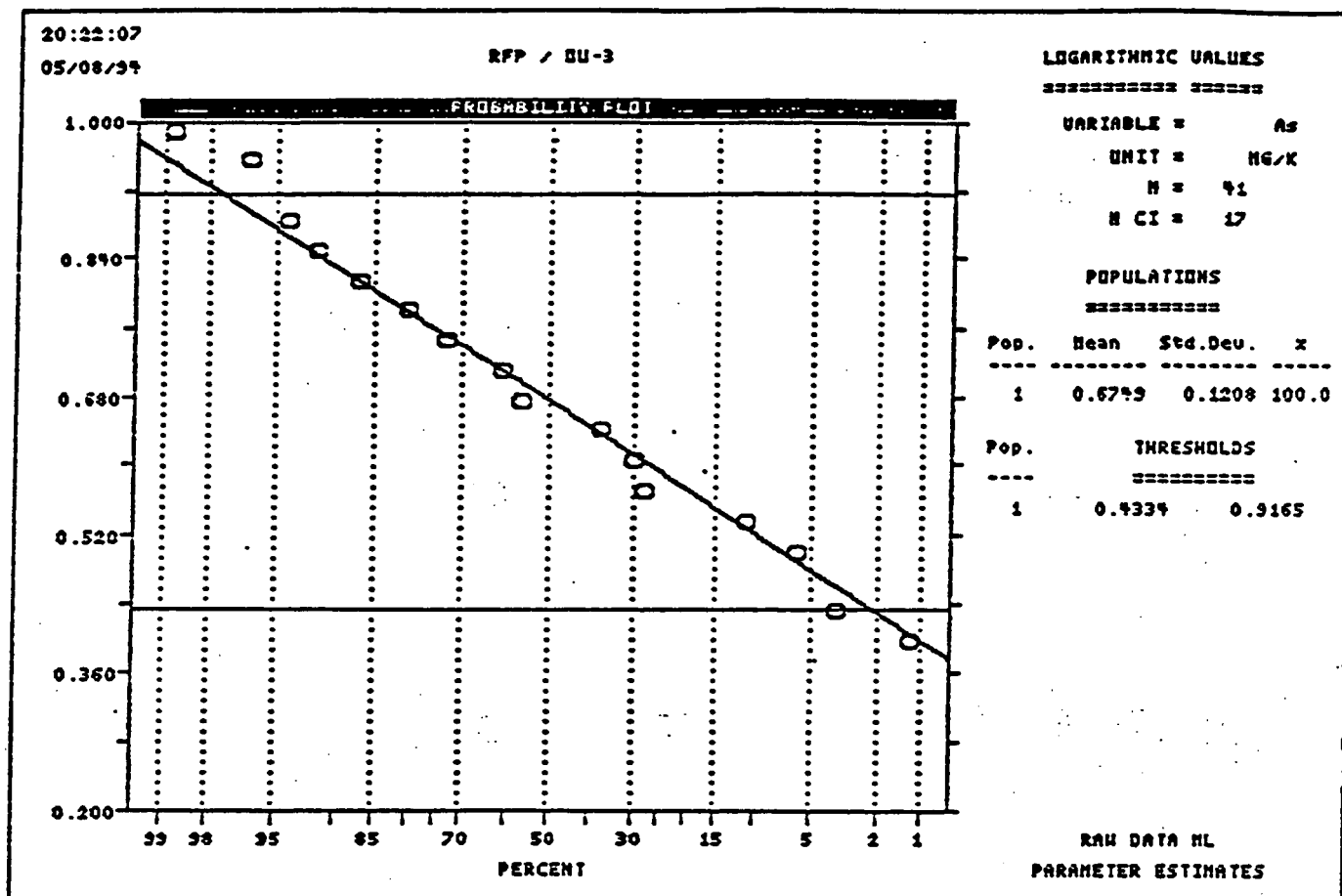


Figure 8-7
ARSENIC IN IHSS 200
SURFACE SEDIMENT

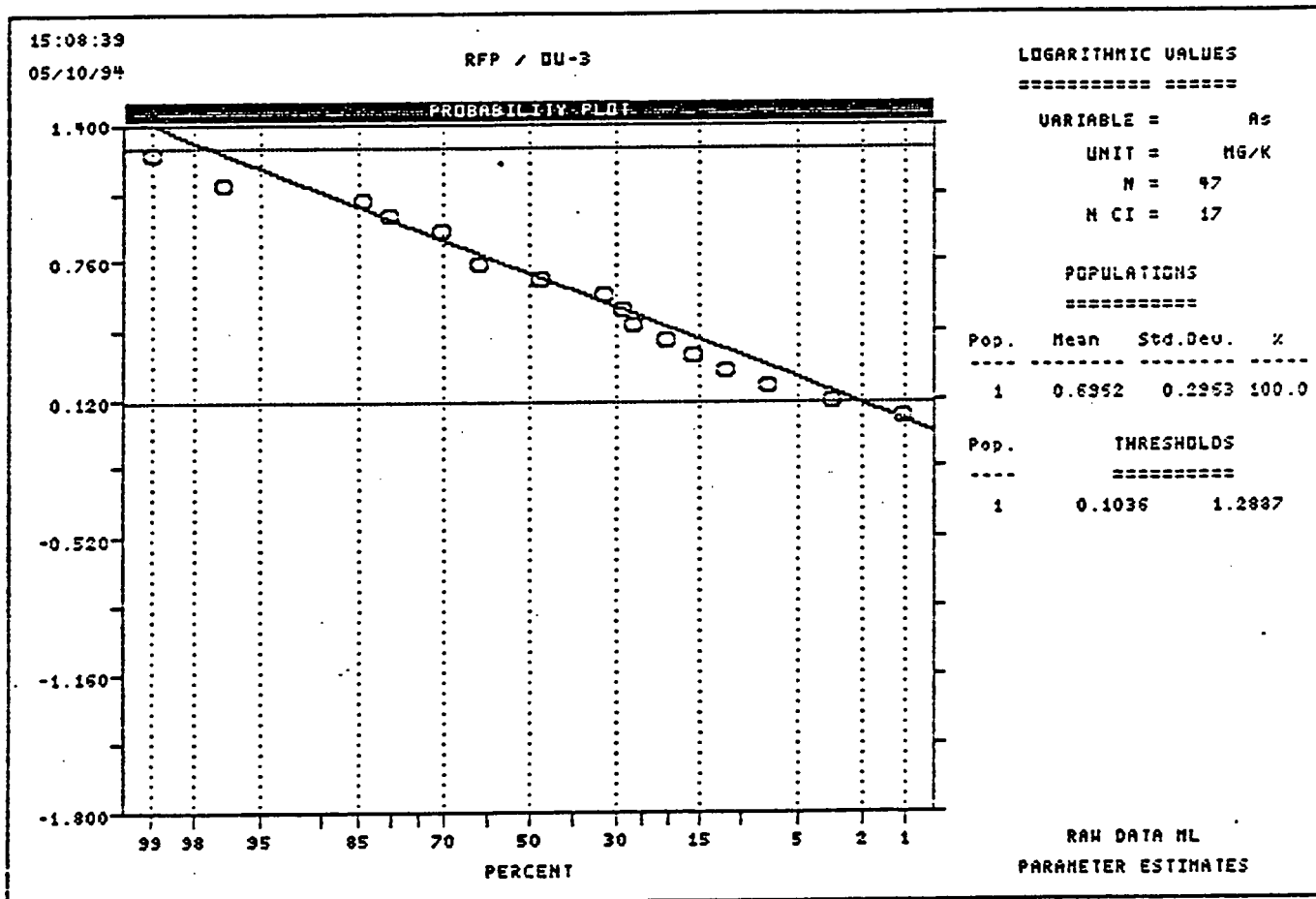


Figure 8-8
ARSENIC IN IHSS 201
SURFACE SEDIMENT

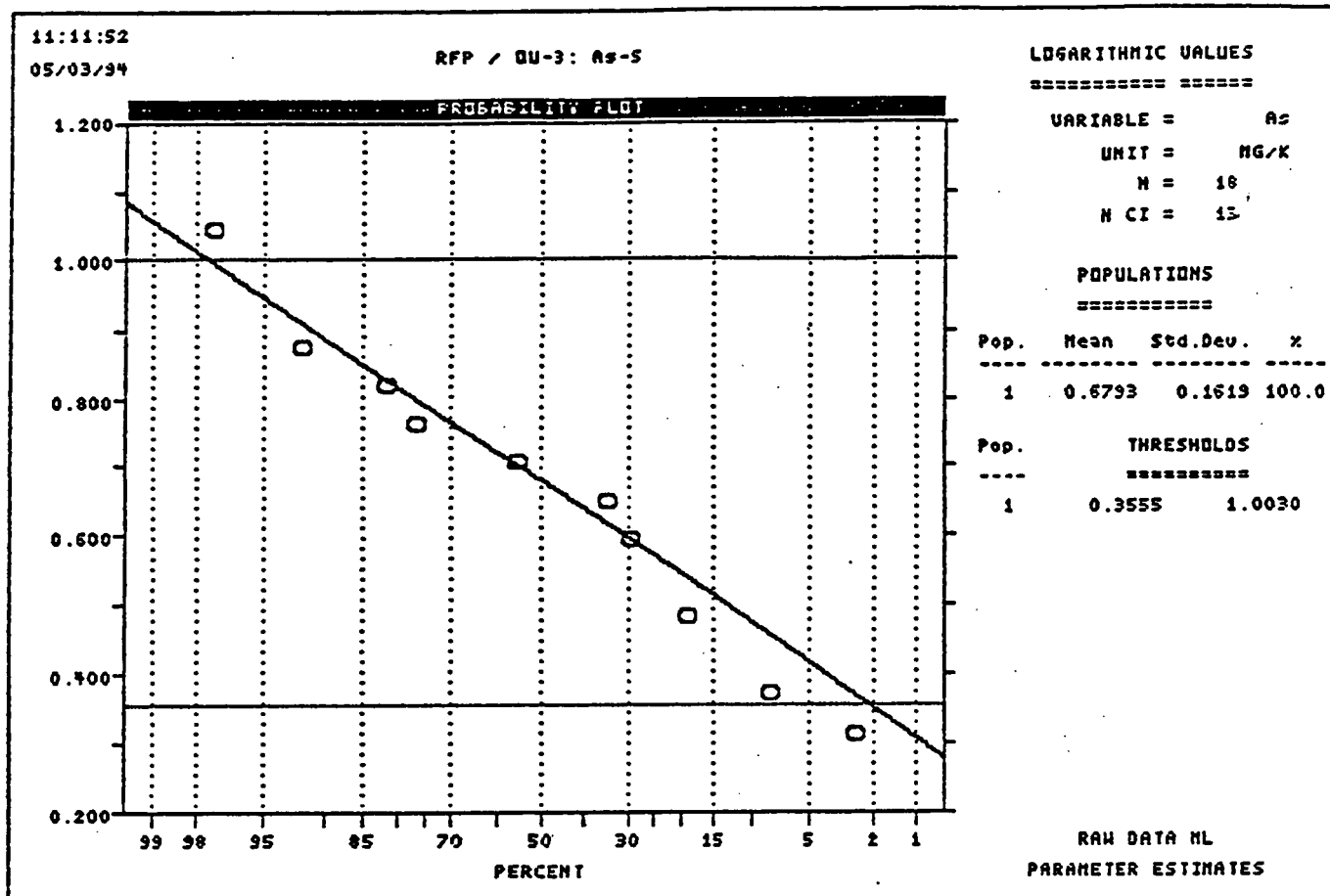
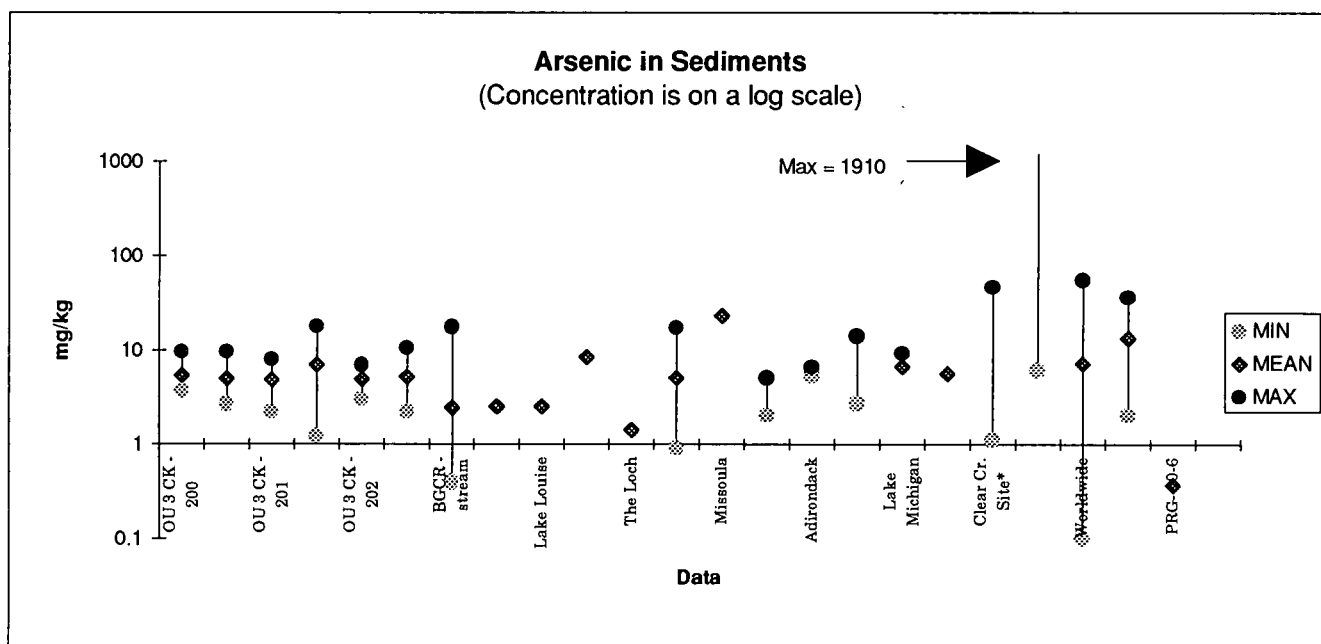


Figure 8-9
ARSENIC IN IHSS 202
SURFACE SEDIMENT

ARSENIC IN SEDIMENTS

(mg/kg)

DATA	MIN	MEAN	MAX	STD DEV	COMMENTS/SOURCE
OU 3 CK - 200	3.7	5.31	9.4	1.85	Great Western Reservoir (Creek) (OU 3 Database)
OU 3 LK - 200	2.6	4.91	9.4	1.46	Great Western Reservoir (Lake) (OU 3 Database)
OU 3 CK - 201	2.2	4.76	7.8	1.53	Standley Lake (Creek) (OU 3 Database)
OU 3 LK - 201	1.2	6.96	17.7	4.34	Standley Lake (Lake) (OU 3 Database)
OU 3 CK - 202	3	4.88	6.8	1.56	Mower Reservoir (Creek) (OU 3 Database)
OU 3 LK - 202	2.2	5.15	10.4	1.96	Mower Reservoir (Lake) (OU 3 Database)
BGCR -stream	0.39	2.4	17.3	2.45	RFP Background Stream Sediments, BGCR (DOE, 1993c)
Lake Husted		2.5		0.2	Rocky Mountain National Park Lake Surface Sediment (Heit et al., 1984)
Lake Louise		2.5		0.3	Rocky Mountain National Park Lake Surface Sediment (Heit et al., 1984)
Lake Haiyaha		8.4		0.2	Rocky Mountain National Park Lake Surface Sediment (Heit et al., 1984)
The Loch		1.4		0.2	Rocky Mountain National Park Lake Surface Sediment (Heit et al., 1984)
Lowry	0.9	5	17	4	Lowry Landfill Background Stream Sediment OUs 2-5 Baseline Risk Assessment (EPA, 1992)
Missoula		23			Missoula Lake Beds Surface Sediment (Moore and Ramamoorthy, 1984)
Great Lakes	2		5		Great Lakes Surface Sediment (Fergusson, 1990)
Adirondack	5.3		6.5		Lake Adirondack Surface Sediment (Fergusson, 1990)
Niagara R.	2.7		14		Niagara River Sediment (polluted) (Fergusson, 1990)
Lake Michigan		6.6	9.2		Lake Michigan Surface Sediment (Fergusson, 1990)
Cherry Creek		5.57			Cherry Creek Reservoir Surface Sediment (CCBA, 1994)
Clear Cr. Site*	1.1		46		Clear Creek Superfund Site (CDPHE, 1990)
Warm Springs*	6		1910		Warm Springs Pond Superfund Site, Pond Bottom Sediments (EPA, 1988)
Worldwide	0.1	7.2	55	7.2	Worldwide Sediment (Boyle & Jonasson, 1973)
Peaty Soils	2	13.4	36	9.4	Peaty Soils (Boyle & Jonasson, 1973)
PRG-10 ⁶		0.37			10 ⁶ PRG level based on a residential soil scenario (EG&G, 1994a)



Notes: If blank, no data are available.

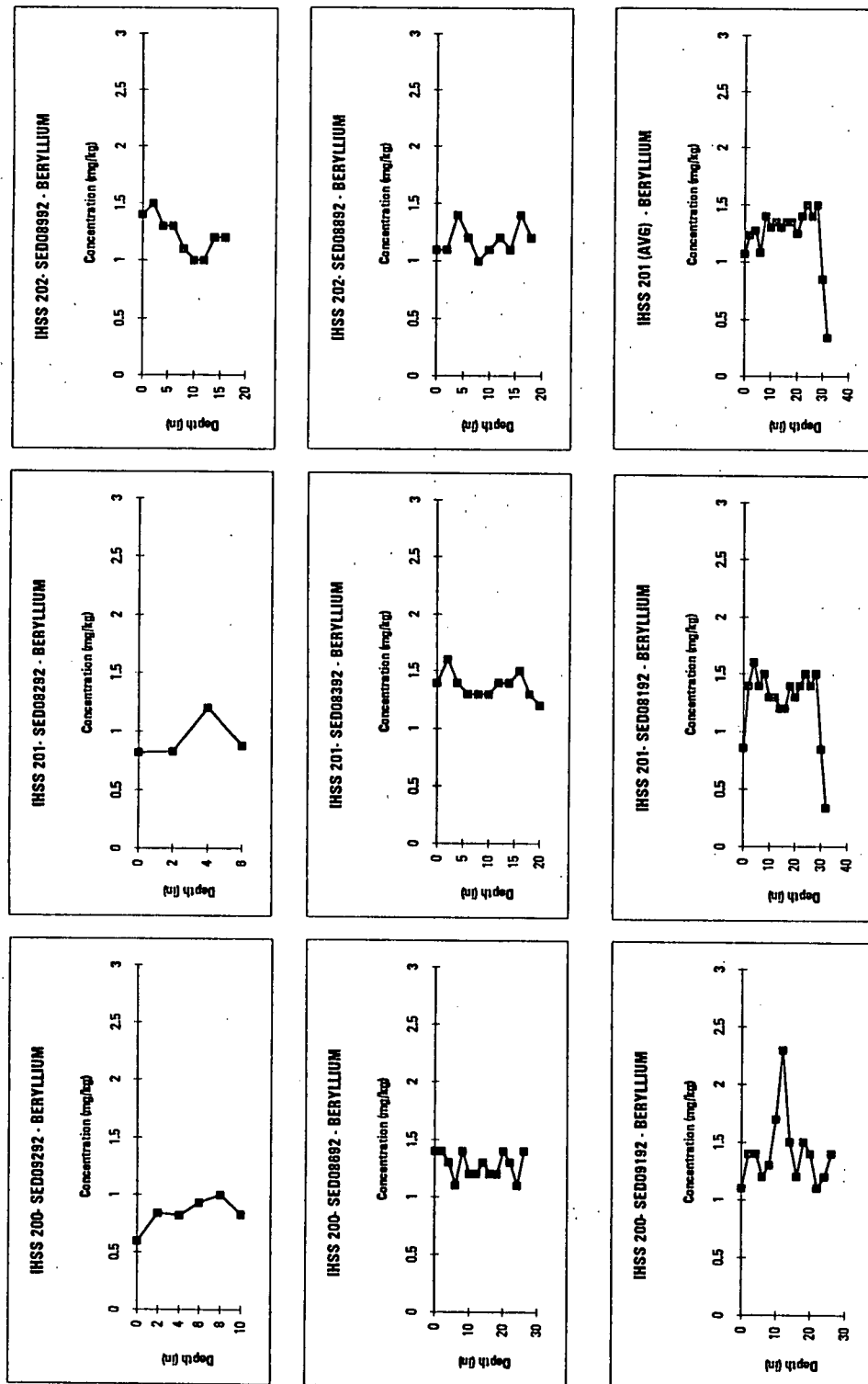
*Indicates Superfund site.

OU 3 CK-200 = Creek sediment data in IHSS 200.

OU 3 LK-200 = Lake sediment data in IHSS 200.

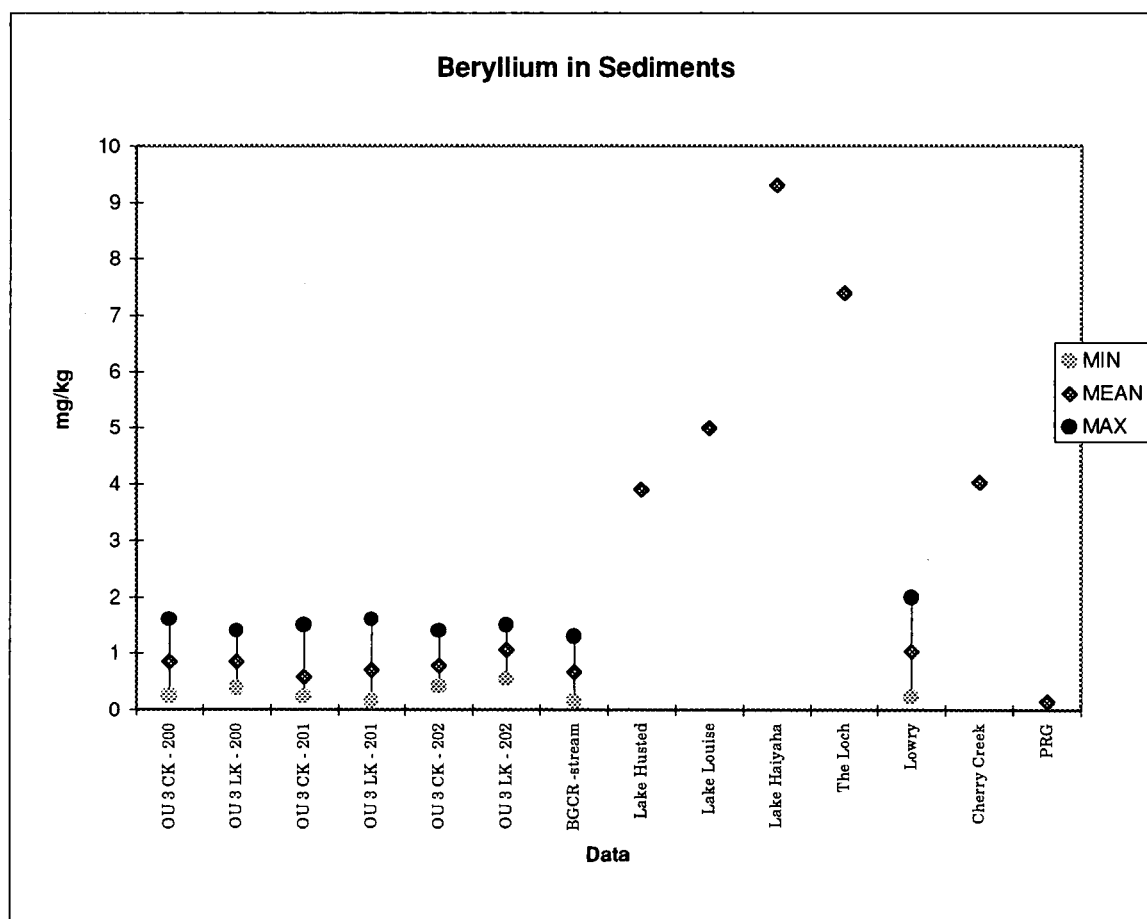
Figure 8-10
ARSENIC IN SEDIMENTS

Figure 8-11 Sediment Core Plots - Beryllium



BERYLLIUM IN SEDIMENTS

(mg/kg)					
DATA	MIN	MEAN	MAX	STD DEV	COMMENTS/SOURCE
OU 3 CK - 200	0.24	0.85	1.6	0.38	Great Western Reservoir Surface Sediments (Creek) (OU 3 Database)
OU 3 LK - 200	0.37	0.85	1.4	0.27	Great Western Reservoir Surface Sediments (Lake) (OU 3 Database)
OU 3 CK - 201	0.22	0.58	1.5	0.31	Standley Lake Surface Sediments (Creek) (OU 3 Database)
OU 3 LK - 201	0.15	0.7	1.6	0.47	Standley Lake Surface Sediments (Lake) (OU 3 Database)
OU 3 CK - 202	0.41	0.78	1.4	0.54	Mower Reservoir Surface Sediments (Creek) (OU 3 Database)
OU 3 LK - 202	0.54	1.06	1.5	0.27	Mower Reservoir Surface Sediments (Lake) (OU 3 Database)
BGCR -stream	0.15	0.66	1.3	1.69	RFP Background Stream Sediments, BGCR (DOE, 1993c)
Lake Husted		3.9		1	Rocky Mountain National Park Surface Sediments (Heit et al., 1984)
Lake Louise		5		3	Rocky Mountain National Park Surface Sediments (Heit et al., 1984)
Lake Haiyaha		9.3		1.1	Rocky Mountain National Park Surface Sediments (Heit et al., 1984)
The Loch		7.4		1.3	Rocky Mountain National Park Surface Sediments (Heit et al., 1984)
Lowry	0.23	1.04	2	0.48	Lowry Landfill Background Stream Sediment OUs 2-5 Baseline Risk Assessment (EPA, 1992)
Cherry Creek		4.03			Cherry Creek Reservoir (CCBA, 1994)
PRG		0.15			10 ⁻⁸ PRG level based on a residential soil scenario (EG&G, 1994a)



Notes: If blank, no data are available.

OU 3 CK-200 = Creek sediment data in IHSS 200.

OU 3 LK-200 = Lake sediment data in IHSS 200.

Figure 8-12
BERYLLIUM IN SEDIMENTS

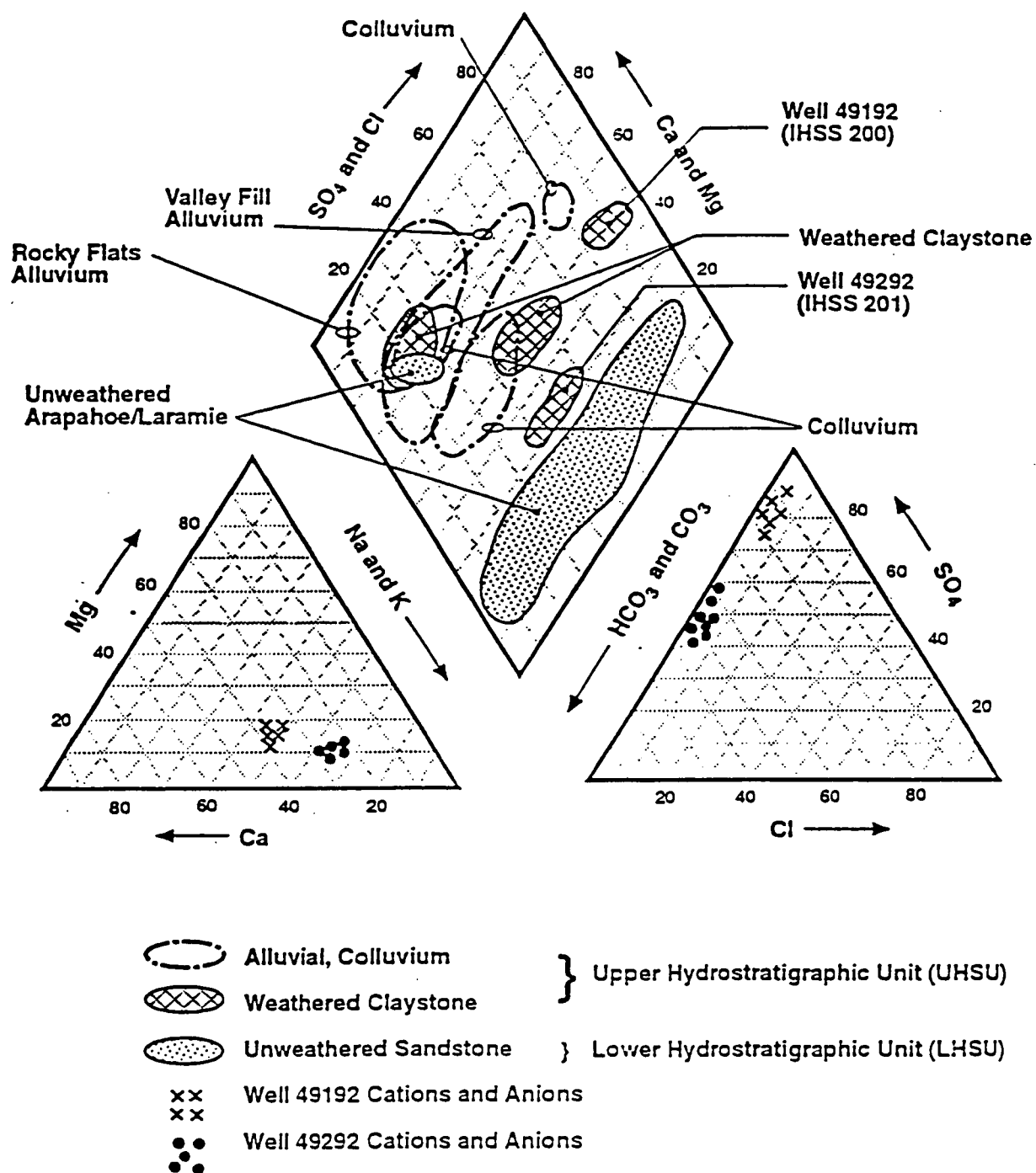
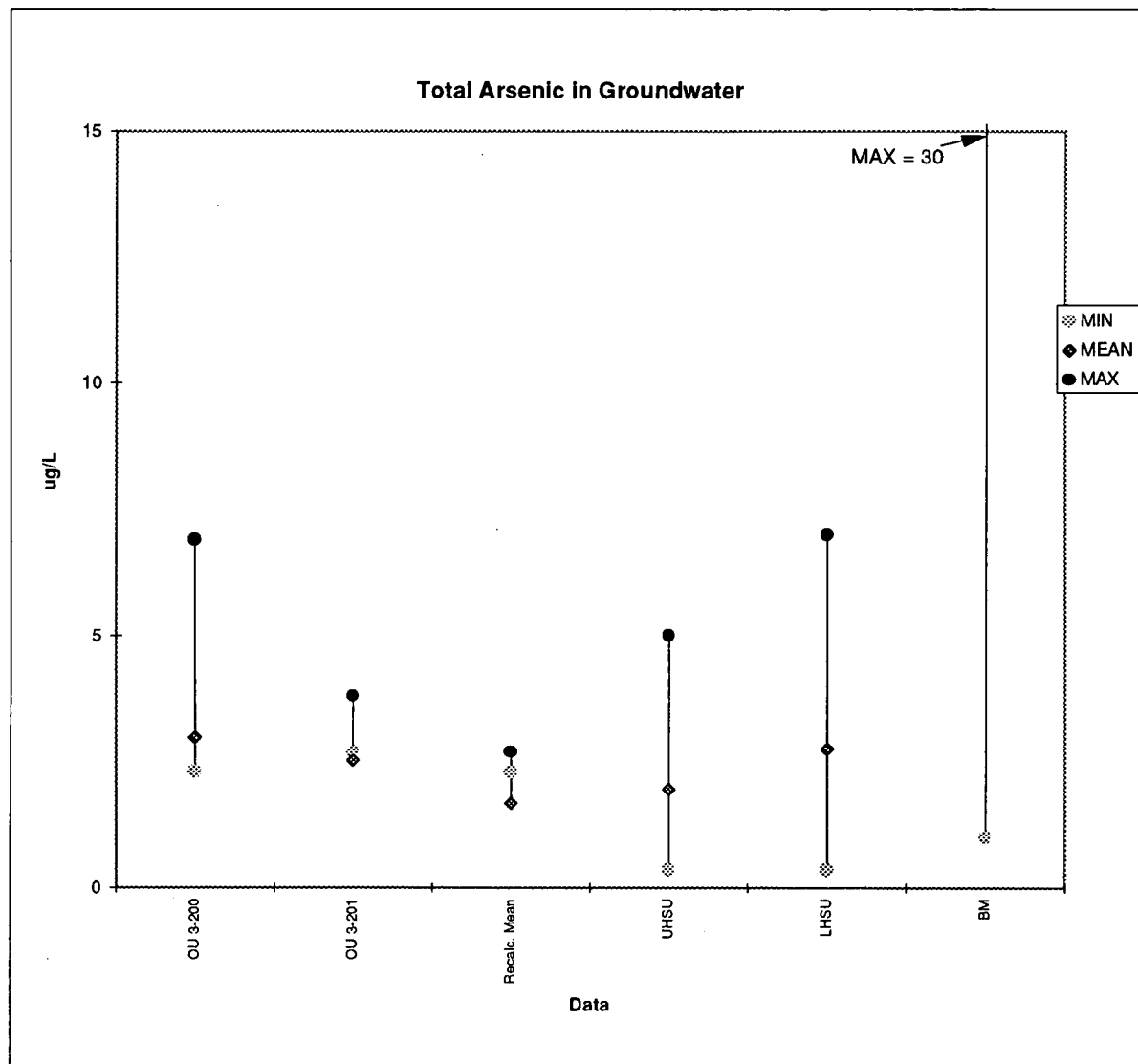


Figure 8-13

PIPER DIAGRAM SHOWING MAJOR ION CHEMISTRY
FOR OU 3 WELLS AND BACKGROUND GEOCHEMICAL
GROUNDWATER WELLS

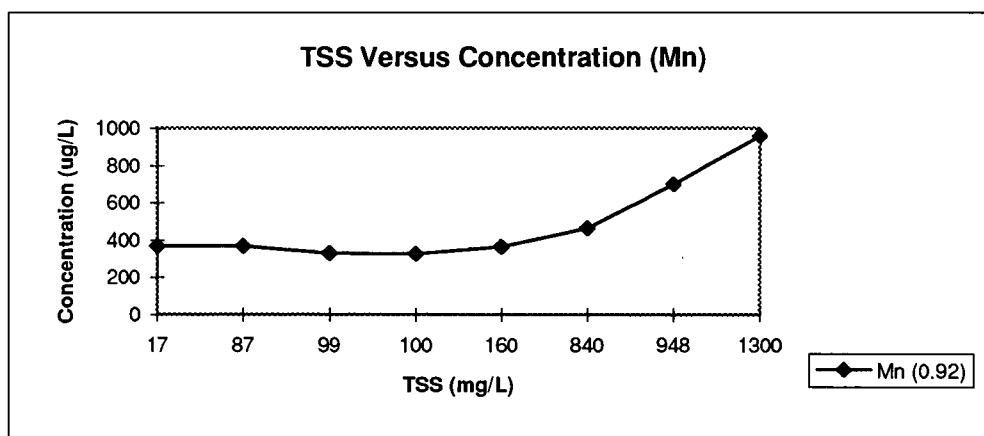
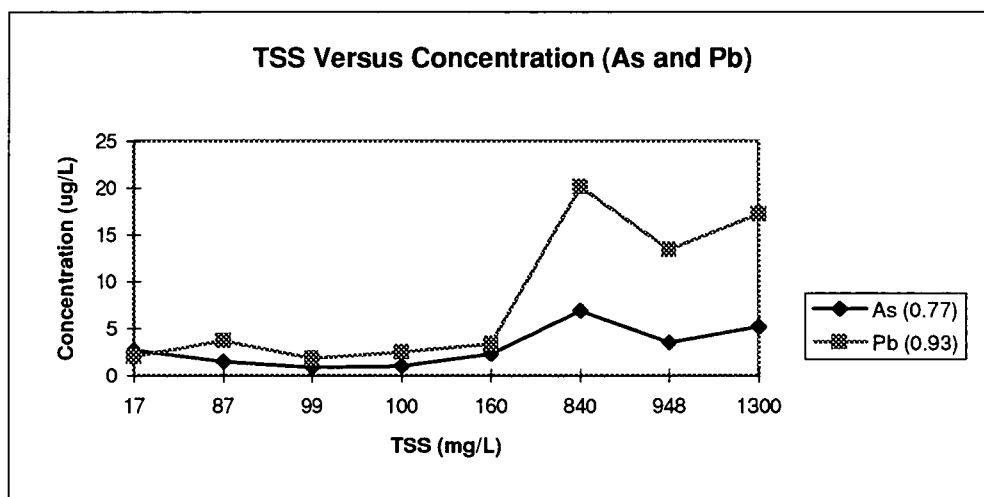
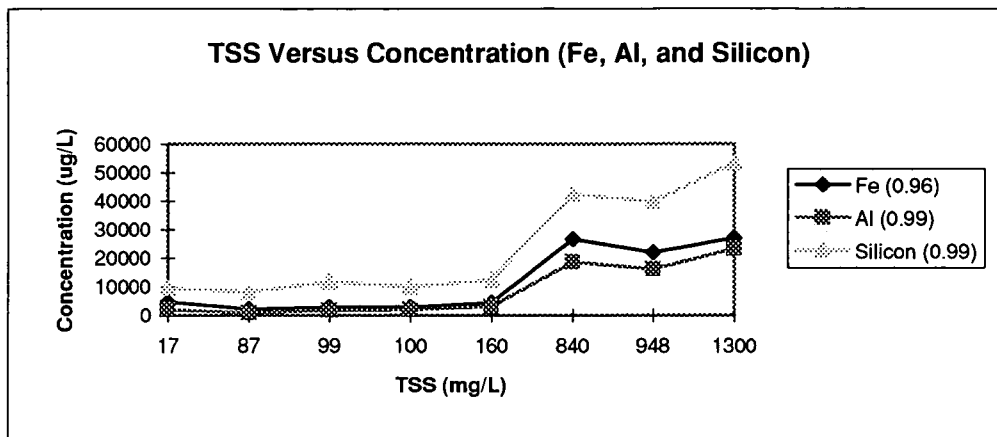
TOTAL ARSENIC IN GROUNDWATER

DATA	MIN	MEAN	MAX	STD DEV	COMMENTS/SOURCE
OU 3-200	2.3	2.99	6.9	0.711	OU 3 Well 49192 (8 sampling events) (OU 3 Database)
OU 3-201	2.7	2.53	3.8	0.424	OU 3 Well 49292 (8 sampling events) (OU 3 Database)
Recalc. Mean	2.3	1.67	2.7		OU 3 Well 49192 recalculated without sampling events associated with high TSS
UHSU	0.35	1.95	5	1.71	Weathered Claystone, BGCR (DOE, 1993c)
LHSU	0.35	2.76	7	2.02	Unweathered Arapahoe and Laramie Formation, BGCR (DOE, 1993c)
BM	1		30		Benchmark Data (Dragun, 1988)



Notes: If blank, no data are available.
OU 3-200 = IHSS 200 in OU 3.

Figure 8-14
TOTAL ARSENIC IN GROUNDWATER



Note: Values in () are correlation coefficients

Figure 8-15
TSS VERSUS CONCENTRATION FOR WELL 49192

Table 2-1 Reasons for the Weight-of-Evidence Evaluation		
Medium	Reason(s)	Discussion
Reservoir sediment (All IHSSs)	No comparable background data set	The Background Geochemical Characterization Report (BCGR) does not contain sediment data from background reservoirs, lakes, or ponds. No other data sets from reservoirs along the front range were found with adequate sample size. Although other OUs used background seep data from the BGCR, there is no evidence to support that the seep data is comparable to the OU 3 reservoir data.
Stream sediment: IHSS 200: 8 samples IHSS 201: 14 samples IHSS 202: 4 samples Stream surface water: IHSS 200: 4 total/1 dissolved IHSS 201: 4 total/2 dissolved IHSS 202: 0 Groundwater: IHSS 200: 1 well sampled 8 times IHSS 201: 1 well sampled 8 times	1. Too few OU 3 samples 2. Disproportionate sample sizes Background Data from the BGCR: Stream Sediments: 20-60 Stream Surface Water: 100 Groundwater: 49 wells (157 samples)	1. Satisfactory confidence and power in the inferential rigorous statistical tests was not possible because of the confirmation sampling approach. 2. Rigorous inferential statistics could not be employed with confidence owing to disproportionate sample sizes between the OU 3 and background data sets.
Reservoir surface water	No comparable background data set	The Background Geochemical Characterization Report does not contain surface water data from background reservoirs, lakes, or ponds. No other data sets from reservoirs along the front range were found with adequate sample size.

TABLE 8-1

FRONT RANGE SOURCES CONTACTED AS PART OF BENCHMARK DATA COLLECTION ACTIVITIES

Source	Media	Parameter(s)
Aurora Reservoir Water Quality Control	Surface Water	Metals
Arvada Department of Water and Environmental Quality	Surface Water	Metals
Background Geochemical Characterization Report	Surface Water	Metals/Radionuclides
Bear Creek Water and Sanitation District	Surface Water	Metals/Radionuclides
Boulder Department of Water and Environmental Quality	N/A	N/A
Broomfield Department of Water and Environmental Quality	N/A	N/A
Chatfield Basin Authority	Surface Water	Metals
Cherry Creek Basin Authority	Surface Water/Sediment	Metals
Colorado School of Mines	Sediment	Radionuclides
Coors Brewing Company	N/A	N/A
Denver Regional Council of Governments	Surface Water/Sediment	Metals/Radionuclides
Final Historical Information Summary and Preliminary Health Risk Assessment OU 3 (DOE, 1991b)	Sediment	Radionuclides
Interim Baseline Risk Assessment for the Sharon Steel/Midvale Tailings Site	N/A	N/A
Jefferson County Health Department	N/A	N/A
Last Chance Dam and Reservoir--Preliminary Feasibility Study	Soils	Metals
Rocky Flats Program Unit	N/A	N/A
Rocky Flats Reading Room	Surface Water	Radionuclides
Superfund Records Center	Surface Water/Sediment/Soils	Metals
U.S. Army Corps of Engineers	Surface Water/Sediment	Metals/Radionuclides
U.S. Geological Survey Library	N/A	N/A
U.S. Geological Survey Water Resources Division	N/A	N/A
University of Colorado at Boulder	N/A	N/A
Water Quality Control Division--STORET (EPA, 1993DB and 1994DB)	Surface Water	Metals
Westminster Department of Water and Environmental Quality	N/A	N/A

N/A = No available data.

TABLE 8-2
SUMMARY STATISTICS FOR SURFACE SEDIMENTS BY IHSS FOR WEIGHT-OF-EVIDENCE EVALUATIONS

Chemical Name	IHSS or Benchmark	Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation	Coefficient of Variation
METALS (mg/kg)													
ARSENIC	BGCR	CREEK	B	53	59	1.00			0.20	17.30	2.410	2.45	
ARSENIC	200	CREEK	S	8	8	1.00			3.70	9.40	5.313	1.85	0.35
ARSENIC	201	CREEK	S	14	14	1.00			2.20	7.80	4.764	1.53	0.32
ARSENIC	202	CREEK	S	4	4	1.00			3.00	6.80	4.875	1.56	0.32
ARSENIC	BM	LAKE	B						0.79	8.400	5.57		
ARSENIC	200	LAKE	S	36	36	1.00			2.60	9.40	4.906	1.46	0.30
ARSENIC	201	LAKE	S	43	43	1.00			1.20	17.70	6.963	4.34	0.62
ARSENIC	202	LAKE	S	15	15	1.00			2.20	10.40	5.147	1.96	0.38
ARSENIC	RMNP-BM (L. Husted)	LAKE	B								2.5	0.2	
ARSENIC	RMNP-BM (L. Louise)	LAKE	B								2.5	0.3	
ARSENIC	RMNP-BM (L. Haiyaha)	LAKE	B								8.4	0.2	
ARSENIC	RMNP-BM (The Loch)	LAKE	B								1.4	0.2	
ARSENIC	LOWRY	CREEK	B							16.50	4.81	3.95	
BERYLLIUM	BGCR	CREEK	B	27	57	0.47			1.50	1.30	0.660	1.69	
BERYLLIUM	200	CREEK	S	8	8	1.00			0.24	1.60	0.851	0.38	0.45
BERYLLIUM	201	CREEK	S	14	14	1.00			0.22	1.50	0.577	0.31	0.54
BERYLLIUM	202	CREEK	S	3	3	1.00			0.41	1.40	0.783	0.54	0.69
BERYLLIUM	BM	LAKE	B						3.90	4.03	9.300		
BERYLLIUM	200	LAKE	S	36	36	1.00			0.37	1.40	0.850	0.27	0.31
BERYLLIUM	201	LAKE	S	39	43	0.91	0.06	0.07	0.15	1.60	0.700	0.47	0.67
BERYLLIUM	202	LAKE	S	13	14	0.93	1.00	1.00	0.54	1.50	1.061	0.27	0.25
BERYLLIUM	RMNP-BM (L. Husted)	LAKE	B								3.9	1.0	
BERYLLIUM	RMNP-BM (L. Louise)	LAKE	B								5.0	3.0	
BERYLLIUM	RMNP-BM (L. Haiyaha)	LAKE	B								9.3	1.1	
BERYLLIUM	RMNP-BM (The Loch)	LAKE	B								7.4	1.3	
BERYLLIUM	LOWRY	CREEK	B							2.1	1.0	0.5	

BGCR = Background Geochemical Characterization Report (DOE, 1993b)
 CC-BM = Cherry Creek Reservoir Surface Sediment (n=1) (CCBA, 1994)
 RMNP-BM = Rocky Mountain National Park Lakes Surface Sediment Data (Heit, et al., 1984)
 LOWRY = Lowry Landfill Site Background Data (Stream Sediment) (EPA, 1992)

B = Background.
 S = Site.

Table 8-3			
Arsenic Concentrations in Surface Sediments			
IHSS	Stream Sediments	Nearshore Sediments	Middle of Reservoir Sediments
	Minimum - Maximum (mg/kg)	Minimum - Maximum (mg/kg)	Minimum - Maximum (mg/kg)
200	4.5 to 4.6	2.8 to 9.4	3.6 to 9.4
201	2.2 to 5.4	1.2 to 8.7	5.7 to 17.7
202	3.0 to 5.1	2.2 to 6.8	2.7 to 10.4

Table 8-4			
Arsenic Concentrations Subsurface Sediments (Cores)			
IHSS	Minimum (mg/kg)	Mean (mg/kg)	Maximum (mg/kg)
200	3.6	6.5	10.4 at 2 to 4 in.
201	5.7	12.3	36.2 at 20-22 in.
202	2.6	4.7	8.9 at 0 to 2 in.

TABLE 8-5

SUMMARY STATISTICS BY WELL FOR OU 3 FOR PARAMETERS EXCEEDING PRGs

				OU 3 Groundwater Data										Background Geochemical Characterization Report Data (DOE, 1993c)						Benchmark Data					
				Upper Hydrostratigraphic Unit (UHSU)										Lower Hydrostratigraphic Unit (LHSU)											
Well #	Test Group	Chemical	Unit of Measure																						
				No. of Detects	No. of Samples	Frequency of Detection	Minimum Nondetect	Maximum Nondetect	Minimum Detect	Maximum Detect	Arithmetic Mean	Standard Deviation	Coefficient of Variation	Minimum	Maximum	Arithmetic Mean	Standard Deviation	Mean Plus 2 Standard Deviations	Minimum	Maximum	Arithmetic Mean	Standard Deviation	Mean Plus 2 Standard Deviations	Minimum (Dragun, 1988)	Maximum (Dragun, 1988)
HSS 200	TMETAL ARSENIC	µg/L		5	8	0.625	1.7	3	2.3	6.9	2.994	2.13	0.71	0.35	5	1.95	1.71	5.37	0.35	7	2.76	2.02	6.8	<1	30
				4	8	0.5	1	1	1.1	1.6	0.913	0.47	0.52	0.4	4.8	1.07	0.87	2.81	0.3	2.5	0.86	0.74	2.34	<10	10
				2	2	1			3.4	4.6	4	0.85	0.21	0	164	15.62	38.75	93.12	0.15	1.52	0.77	0.57	1.91		
HSS 201	TMETAL ARSENIC	µg/L		5	8	0.625	2	3	2.7	3.8	2.525	1.07	0.42	0.35	5	1.95	1.71	5.37	0.35	7	2.76	2.02	6.8	<1	30
				4	8	0	1	1						0.4	4.8	1.07	0.87	2.81	0.3	2.5	0.86	0.74	2.34	<10	10
				2	2	1			0.64	0.87	0.755	0.16		0	164	15.62	38.75	93.12	0.15	1.52	0.77	0.57	1.91		
49292 TRADS	URANIUM 233/234pCi/L	pCi/L		5	8	0.625	2	3	2.7	3.8	2.525	1.07	0.42	0.35	5	1.95	1.71	5.37	0.35	7	2.76	2.02	6.8	<1	30
				4	8	0	1	1						0.4	4.8	1.07	0.87	2.81	0.3	2.5	0.86	0.74	2.34	<10	10
				2	2	1			0.64	0.87	0.755	0.16		0	164	15.62	38.75	93.12	0.15	1.52	0.77	0.57	1.91		

TMETAL = Total metals

TRADS = Total radionuclides

APPENDIX A.

PROBABILITY PLOT ANALYSIS

A probability plot analysis was performed on selected chemicals in surface sediments and surface water to assess whether a chemical concentration/activity data set (i.e., population) represents either a background (natural or anthropogenic in the case of global fallout of radionuclides) or contaminated population. A contaminated population may indicate the chemical is a chemical of concern (COC). This analysis was performed using a statistical software program called PROBPLOT. PROBPLOT was used to define the number of populations present and the concentration/activity range for each population. A description of the results and methods of the probability plot analysis are presented in this appendix.

The analysis indicated the presence of one statistically normal population for each of the metals and radionuclides in each of the IHSS with the exception of aluminum, chromium, manganese, and ^{239/240}Pu in Mower Reservoir (IHSS 202) and chromium in Great Western Reservoir (IHSS 200) (Table G-1). In these cases where two populations were identified, the concentration/activity variations represent subpopulations within the population and are attributed to geochemical (complexation, adsorption, dissolution, precipitation), organic (aquatic organisms, plants, and detritus), and physical processes (transport and deposition) that collectively cause natural variability. The final decision whether a chemical is a COC will be made after reviewing the other weight-of-evidence evaluation results.

A more detailed description of the results and methods employed in the evaluation is included in this appendix, which is divided into the following sections:

- PROBPLOT Procedure (Section A.2)
- Data Input (Section A.3)
- Data Interpretation for Sediments (Section A.4)
- Data Interpretation for Surface Water (Section A.5)
- PROBPLOT Output (Section A.6)
- References

A.2 PROBPLOT PROCEDURE

PROBPLOT is an interactive software tool (Stanley, 1987) that allows a user to statistically evaluate cumulative frequency distributions for a given data set. The PROBPLOT analysis determines the number of populations and statistical boundaries present. The software program was used to

Table A-1

**RESULTS OF PROBABILITY PLOT ANALYSIS
NUMBER OF DATA POPULATIONS**

Chemical	Surface Sediments IHSS			Surface Water
	200	201	202	IHSSs Combined
Aluminum	1	1	2 ^N	--
Arsenic	1	1	1	1
Beryllium	1	1	1	--
Cadmium	1	1	1	--
Chromium	2 ^N	1	2 ^N	--
Cobalt	1	1	1	--
Iron	1	1	1	1
Lead	1	1	1	1
Lithium	1	1	1	--
Manganese	1	1	2 ^N	1
Mercury	1	1	1	--
Nickel	1	1	1	--
Silicon	1	1	1	1
Zinc	1	1	1	--
^{239/240} Pu	1	1	2 ^N	--
^{233/234} U	1	1	1	--
²³⁴ U	1	1	1	--

Notes:

- = Analysis not performed.

One population may indicate chemical is not a COC. Population represents background conditions.

Two or more populations may indicate chemical is a COC.

N = Second population is attributed to natural background processes.

Chemical does not appear to be a COC.

evaluate the concentration/activity distributions of specific metals and radionuclides contained in sediment and surface water samples at OU 3. The distribution information was used to define the number of populations present and the concentration range for each population and each metal/radionuclide data set. PROBPLOT has been used at the Operating Industries, Inc. (OII) Superfund site (EPA, 1994), the Lawrence Livermore National Laboratory (DOE, 1994), and has been used extensively by the mining industry for over 20 years to identify geochemical anomalies for exploration (Sinclair, 1986; Sinclair, 1976; Stanley, 1987).

The computer analysis in PROBPLOT compares the actual cumulative frequency distribution for given data sets with that of a normally distributed population. In a cumulative frequency distribution, the concentration frequencies of a distribution are cumulated from low to high values. Cumulating from low to high produces a "less than" distribution where each cumulative frequency includes all concentrations/activities that are less than a given value. The model is flexible; it is capable of representing numerous forms of frequency distributions consisting of combinations of normal or lognormal component populations.

PROBPLOT generates a probability plot that presents the distribution for each population identified within a data set. The mean plus two standard deviations (i.e., threshold) value is also summarized for each population.

A.3 DATA INPUT

Metal and radionuclide concentrations/activities from the surface-sediment and surface-water samples collected from Great Western Reservoir (IHSS 200), Standley Lake (IHSS 201), and Mower Reservoir (IHSS 202) for the RFI/RI for OU 3 were analyzed using PROBPLOT. Surface-sediment samples, collected in each reservoir and in the adjoining creeks for each of the IHSSs, were used in the PROBPLOT analyses. Only concentration data reported above the detection limit (i.e., detects) were used in the PROBPLOT analysis. The concentration/activity data were logtransformed before being input into PROBPLOT because natural environments are typically lognormally distributed (Rose, 1979). If multiple samples were collected at a given location, the data values for the additional samples were averaged prior to analysis. However, for Mower Reservoir, if a given location was sampled more than once, the samples were treated as individual samples and not averaged. This was done in order to have a sufficient number of data points for the PROBPLOT analysis. (A minimum of 15 points is required by the PROBPLOT program to define populations [Stanley, 1987].) The following metals and radionuclides for sediments at each IHSS were evaluated:

- | | |
|-------------|-------------------------|
| • Aluminum | • Manganese |
| • Arsenic | • Mercury |
| • Beryllium | • Nickel |
| • Cadmium | • Silicon |
| • Chromium | • Zinc |
| • Cobalt | • $^{233/234}\text{U}$ |
| • Iron | • ^{235}U |
| • Lead | • $^{239/240}\text{Pu}$ |
| • Lithium | |

A probability plot for every metal is not included in this appendix. A subset was selected based on their potential toxicity. Additional metals were selected to provide information on the potential geochemical association with other metals or processes. For example, cobalt and nickel are similar in chemical behavior. Therefore, information on each of these metals can be used to confirm the conclusions made.

Surface-water samples were collected in the streams upgradient to RFP to establish background levels. The background data sets were collected from areas considered unimpacted by RFP activities and are described in the Background Geochemical Characterization Report (DOE, 1993). If more than one sample was collected at a given location for either the background or the OU 3 data, each value was used as part of the data set. No averaging of the data was performed. Only detected data were used in the analysis. Surface-water data collected (creek and reservoir data) for the three IHSSs (Great Western Reservoir-200, Standley Lake-201, and Mower Reservoir-202) were combined with background data to determine if more than one population was present. The background and OU 3 surface-water data were combined to have a sufficient number of samples (i.e., 15 or greater) because some of the metals had low detection frequencies. Probability plots were generated for arsenic, lead, manganese, iron, and silicon. These metals were selected based on their toxicity factors and potential association with other metals and geochemical processes.

A.4 DATA INTERPRETATION FOR SEDIMENTS

This section presents the interpretation of the probability plots for the surface-sediment data. Based on the PROBPLOT analysis, the chemicals in the OU 3 surface sediment exhibit low concentrations/activities of naturally occurring metals and radionuclides and appear to represent a single, background population (see Table G-1). This subsection provides an example of a chemical exhibiting a population that appears to represent contamination, brief descriptions of the processes

that cause variability within a natural background population, and the results for each metal/radionuclide evaluated.

For OU 3 sediments, the metal/radionuclide analytical results for samples from each of the three reservoirs were evaluated separately. However, the creek sediment data associated with each reservoir were included with reservoir sediments in the data sets. This was done in order to evaluate the complete physical system of the reservoir.

Geochemical evaluations (of all the metals/radionuclides in total), the low concentrations present, geologic setting, and available background and benchmark data indicate the population identified in PROBLOT represents a statistically normal background population.

Where more than one population is identified in PROBLOT, the two populations can either represent background and contamination (depending on the magnitude of differences for each population) or represent natural physical processes within the background population that result in a concentration/activity slightly elevated above the upper limit background concentration/activity.

To illustrate a scenario where a probability plot shows two populations that represent one background population and one contamination population, the OU 3 $^{239/240}\text{Pu}$ data from surface-soil samples were evaluated. Based on the Gilbert statistical analysis (see Subsection 4.3), some of the soil sample activity values were above background; however, most were below background. Therefore, the OU 3 soil sample results represent two populations (one background and one with elevated $^{239/240}\text{Pu}$ activities). The data set used for the PROBLOT analysis included the OU 3 RFI/RI soil plots plus the Jefferson County Remedy Acres samples.

The histogram and probability plot for the soil data clearly show two separate populations (see Figures G-1 and G-2a). The statistically defined threshold level (defined as the mean plus two standard deviations) is the activity at which background is exceeded in the cumulative frequency distribution and is 0.07 pCi/g for this data set. This value compares favorably with the background mean plus two standard deviations of 0.09 pCi/g that was calculated using the surface-soil background data.

In reviewing the soil probability plot (Figure G-2a), it is important to note that the two population distributions *diverge* with increasing plutonium activities rather than *converge*. In the OU 3 sediment data sets where two populations are identified (for example, aluminum for IHSS 202), the populations *converge* at higher concentrations/activities (Figure G-2b). The convergence of the upper and lower populations indicates that, unlike the diverging populations, these represent two

Figure A-2a
TWO DIVERGING POPULATIONS
PLUTONIUM IN SURFACE SOIL
IHSS 199

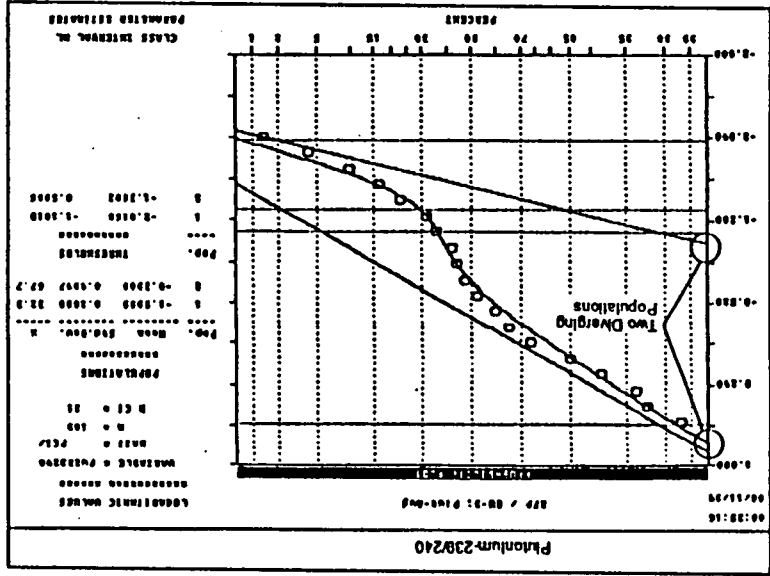
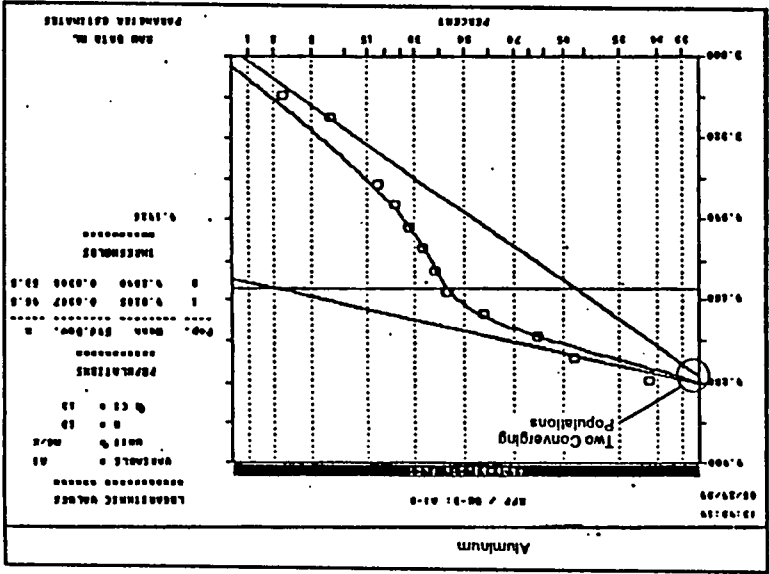
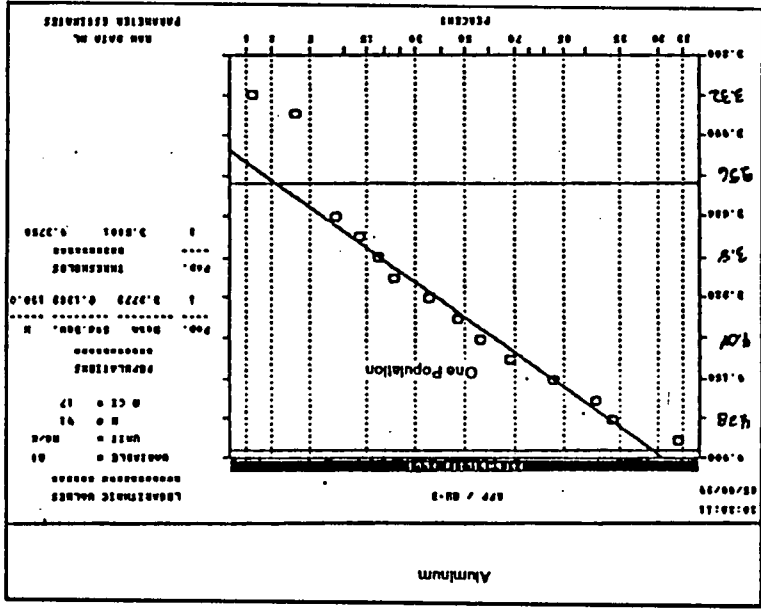


Figure A-2b
TWO CONVERGING POPULATIONS
ALUMINUM IN SURFACE SEDIMENTS
MOWER RESERVOIR (IHSS 202)



ONE POPULATION
ALUMINUM IN SURFACE SEDIMENTS
GREAT WESTERN RESERVOIR (IHSS 200)

Figure A-2c



subpopulations of a single (background) population. The upper subpopulation represents a concentration/activity range of values resulting from precipitation or adsorption of the individual metal/radionuclide. As a comparison, aluminum in Great Western Reservoir (IHSS 202) represents a single, background population (Figure G-2c).

In the sediment PROBPLOT results, most of the plots for a given metal/radionuclide show all the data for an IHSS to be below the threshold value (clearly indicating one population). In the cases where more than one population is identified, the threshold values for the two populations are similar (indicating the second population is due to natural processes and not contamination).

The overall OU 3 data sets exhibit a range of concentrations/activities within expected natural ranges for sediment data, as seen in the benchmark comparison described in previous sections of TM 4. The logarithmic values for the metals and the radionuclides evaluated range from approximately -0.4 to almost 5; yet the logarithmic values of the standard deviations range from only 0.1 to 0.4 with an average of approximately 0.25. In other words, there is little variation from the mean concentrations/activities, regardless of the value of the mean metal or radionuclide concentration/activity for the OU 3 sediments. If concentration levels were the result of contamination, there would be higher standard deviations for the contaminating constituents (Rose et al., 1979). These small, similar standard deviations suggest that the sediments probably represent background conditions and are within naturally expected variability.

A.4.1 Reasons for Naturally Occurring Variability

Several physiochemical processes cause variability in sediments in nature, depending on geologic setting. The predominant processes causing variability within OU 3 sediments are described in the following paragraphs.

Geochemical Processes

The sediment grab samples were collected from both the streams draining into the reservoir and the reservoir itself. Within the reservoir, sediment samples were collected from both peripheral (inlets, shoreline, and adjacent to the dam) and central parts of the reservoir. Each of the individual sediment sample locations represent unique local environments with differing microbiota, physicochemical conditions, water depth, and flow regimes. Each environment results in spatially variable concentrations of metals and/or radionuclides. For example, streams have significantly higher flow velocities than reservoirs; this generally results in coarser-grained sediment, oxygenated water (i.e., oxidizing oxidation-reduction (Eh) conditions), near-neutral pH, and a highly variable

aerobic microbiotic and aquatic population (Rose et al., 1979). Coarse-grained sediments typically have lower metal concentrations in comparison to finer-grained sediments because of the lower surface area for a given volume of sediment; this results in a lower number of sorption sites (Davis and Kent, 1990). Oxidizing conditions with near-neutral pH minimizes the dissolved metals concentrations because metals are least soluble in these environmental conditions (Rose et al., 1979). Compared to the reservoir sediments, the stream sediments have a very low total organic carbon (TOC) and nutrient load; thus, less chemical reactions with organics occur. As a result, lower metal concentrations are expected.

Physical Processes

Shoreline peripheral sediments primarily reflect the local land use, soils, and bedrock composition. The sediment composition can be highly variable because of surface-water runoff, such as irrigation return flow, industrial outfalls, return rills, and sheetflow into the reservoir. Reservoir sediments in the nearshore area (littoral) are generally finer-grained than stream sediments, but much coarser than either the central reservoir or in the area adjacent to the dam.

The central area of the reservoir and the area adjacent to the dam receive the finest-grained material. As a stream enters a reservoir, a deltaic environment at the inlet of the reservoir is created wherein the coarser-grained sediments settle near the inlet as the flow velocity decreases. Finer-grained sediments are transported farther into the reservoir. The finer-grained sediments are a mixture of clay minerals, natural organic acids (humic and fulvic), and iron, manganese, and aluminum oxyhydroxide flocculants (Davis and Kent, 1990). Both the organic acids and the oxyhydroxide flocculants contain variable concentrations of complexed and adsorbed metals (Rose et al., 1979). Generally, only the finest-grained material reaches the reservoir area nearest the dam (the deepest portion of the reservoir).

Organic Processes

In addition, algal growth in the reservoir can change the pH (and to an extent, the Eh) of the reservoir water on not only a seasonal, but also a diurnal, cycle. The pH of reservoir water can change from a near-neutral pH of 7 during darker hours to a more alkaline pH of 8.5 to 9 during the daylight hours (Hem, 1985). This cycle can cause a change in dissolved (at near-neutral pH) versus precipitated (more alkaline pH) metal concentrations. Carbonate minerals (calcium, iron, and, potentially, magnesium and manganese) can be precipitated and become part of the sediments on both diurnal and seasonal cycles, thus causing temporal variations in concentrations (Hem, 1985).

Variability in concentrations/activity can also be caused by how the sample is collected and what materials compose the sample. For example, the more organic-enriched and fine-grained materials in the sample, the greater the concentration of metals (Rose et al., 1979).

As the above discussion illustrates, the variability in stream and reservoir sediment environmental conditions (i.e., sample locations) can result in a concentration/activity range of values within a statistically normal background population; that is, these processes cause natural variability within a population without any contribution from a potential contaminant. When statistically evaluated using cumulative frequency distributions, one population or several subpopulations that are a result of these physiochemical processes may be identified. Two populations may also be identified with one population representing background and one population representing contamination, as seen in the soil plot example in Figures G-1 and G-2. As described in the following paragraphs, most of the metals and radionuclides are defined by a single (low concentration range, similar to benchmark ranges) population that defines background concentration/activity ranges. Each reservoir also has environmental characteristics that cause some differences in concentration and characteristics. These result from natural variation attributable to the physiochemical factors described above.

The PROBPLOT results for each metal and radionuclide that was evaluated are discussed in the following paragraphs. PROBPLOT output for each metal and radionuclide for each IHSS is included in Subsection A.6.

A.4.2 Aluminum

Aluminum is the third most abundant element in the earth's crust (Hem, 1985). Based on the probability plots, one population was identified for Great Western Reservoir and one for Standley Lake. In Mower Reservoir, two populations were identified. The two populations in Mower Reservoir are most likely the result of organic processes occurring in the reservoir and represent subpopulations within a background population, as described in the following paragraphs.

Mower Reservoir sediments have the highest mean and median concentrations (13,300 and 14,600 mg/kg, respectively) but the lowest maximum concentration (18,300 mg/kg) of the three reservoirs. The small range of aluminum concentrations (less than an order of magnitude) between the mean, median, and maximum values indicates physiochemical processes are occurring in Mower Reservoir, thus causing two subpopulations. If contamination were present, a larger difference in the mean, median, and maximum would be expected. This small range in aluminum concentrations and similarity in threshold values for each population is shown on the probability plot by the subpopulations converging at higher concentrations.

In Mower Reservoir, pH fluctuations and algal growth have been observed. The higher pH generated by algae in Mower Reservoir results in clay minerals precipitating out of solution more readily than in the other two reservoirs. Therefore, algal activity increases aluminum concentrations. The kinetics of clay-mineral precipitation increase with pHs above 8 (Stumm, 1990). The clay precipitation also enhances the potential for coprecipitation of metals (calcium, magnesium, sodium, iron, and lithium) into the Mower Reservoir sediments (Deer et al., 1971).

Based on the varying pH in Mower Reservoir, the similarity of the two populations within Mower Reservoir, and the similarity of Great Western Reservoir and Standley Lake, it is most probable that the aluminum in Mower Reservoir sediments represents natural variability within background (two subpopulations within background), and is not representative of a contamination source.

A.4.3 Arsenic

One population was identified for arsenic in each of the three reservoirs, with little difference in arsenic concentrations in Great Western Reservoir and Mower Reservoir; their respective means were 4.7 and 4.8 mg/kg and their respective maximums were 9.4 and 10 mg/kg. Standley Lake has essentially the same mean (5.0 mg/kg) but almost twice the maximum concentration (19 mg/kg) compared to Great Western Reservoir and Mower Reservoir. However, Standley Lake also receives sediments from the highly mineralized Clear Creek drainage, which may account for the higher maximum concentration. The similar mean concentrations of arsenic for the three reservoirs, coupled with the single population defined by the PROBLOT analysis for all three reservoirs, indicates a common background population.

A.4.4 Beryllium

Beryllium in sediments shows no difference in mean (0.78, 0.59, and 0.95 mg/kg for IHSSs 200, 201, and 202, respectively), standard deviation (1.45, 1.84, and 1.47 mg/kg for IHSSs 200, 201, and 202, respectively), and median (0.83, 0.6, 1.1 mg/kg for IHSSs 200, 201, and 202, respectively) concentrations between the three reservoirs. The probability plots for each reservoir also indicate only one population. Because only one population was identified and the concentrations are low (less than 2.1 mg/kg and similar to benchmark data), the beryllium concentrations in sediment represent a background population.

A.4.5 Cadmium

In Great Western Reservoir and Standley Lake, only one population was identified for cadmium, based on the probability analysis. PROBPLOT was not performed for Mower Reservoir because cadmium was not detected in any of the samples. The PROBPLOT results also show all the data for a given IHSS were below the threshold value defined from the cumulative frequency distribution. Cadmium occurs naturally in the surrounding mineralized areas (Sheridan et al., 1967).

A.4.6 Chromium

The PROBPLOT analysis indicates two subpopulations of chromium were identified for Mower Reservoir and Great Western Reservoir but only one population for Standley Lake. In February 1989, a waste chromic acid spill occurred at the RFP. An estimated 750 gallons of chromic acid were discharged into a drain system that flowed to the plant's sewage treatment plant. The chromic acid went through the treatment plant and was discharged to retention pond B-3 (CDPHE, 1994). According to the Phase 1 Health Studies on RFP, "No documentation of off-site contamination was located for the event" (CDPHE, 1994). If releases did occur offsite, Great Western Reservoir would have been the receiving reservoir and its sediments should have the highest chromium concentrations. However, chromium was detected in the highest concentrations in Standley Lake (31.9 mg/kg), and Mower Reservoir (14 mg/kg) had the highest mean concentration. In Great Western Reservoir, the mean and maximum concentrations of chromium were 9.1 mg/kg and 17.9 mg/kg, respectively.

Two subpopulations representing background have been identified in Great Western Reservoir and Mower Reservoir. The two subpopulations (the lower and upper subpopulation distributions) have essentially the same 95th percentile chromium concentration (24.9 and 21.7 mg/kg, respectively, for Great Western Reservoir and 17.6 and 17.6 mg/kg, respectively, for Mower Reservoir). Furthermore, the higher concentration population for each has a lower slope than the lower population (the population distributions converge at the 95-percentile concentration). The upper subpopulation is likely caused by physiochemical processes such as adsorption or precipitation, organic absorption, or algal or microbial bioaccumulation.

The high algal content in Mower Reservoir suggests that organic complexing and absorption, coupled with pH and Eh conditions imposed by the organics, are probably responsible for the two chromium subpopulations. Chromium has a tendency to be cycled by the diurnally changing pH and Eh conditions imposed by the algal organisms. This cycle can cause a change in dissolved versus precipitated metal concentrations.

The micas derived from the pegmatites in the adjacent drainages are the most likely source of chromium-rich micas (Deer et al., 1971).

A comparison of the three reservoir means and medians and probability plots indicates that each reservoir is a normal background population.

A.4.7 Cobalt

Based on the probability plots, one population was identified for each of the three reservoirs. Cobalt concentrations in sediments are essentially the same as the nickel concentrations divided by a value of approximately 2 in all three sediment areas. This close association between cobalt and nickel is common in sediments, regardless of source, because of the similarity in the chemical behavior of the two metals (Deer et al., 1971). This relationship in all three reservoirs indicates that the population represents a background population.

A.4.8 Iron

One population was identified in each reservoir for iron, based on the PROBPLOT analysis. Iron has the second highest metal concentration range in the sediments. Relatively high iron concentrations are typical for sediments from lacustrine environments because the reservoirs collect the iron oxyhydroxide precipitates, and the lacustrine organisms, particularly algae, utilize iron in their metabolic processes. This promotes and retains iron concentrations in the reservoir (Davis and Kent, 1990). There is a seasonal die-off of aquatic organisms, which incorporates a major part of the retained iron into the sediments. The means (16,400, 13,120, and 18,600 mg/kg for IHSSs 200, 201, and 202, respectively) and medians (16,400, 14,150, and 18,300 mg/kg for IHSSs 200, 201, and 202, respectively) for the three reservoirs are similar.

A.4.9 Lead

In each of the three reservoirs, only one population was identified for lead, based on the PROBPLOT analysis. The similarity of the means and medians for the three reservoirs indicates that the background mean and median for lead is between 20 and 30 mg/kg, a narrow range considering the diverse source areas for the three reservoirs.

The maximum concentration of lead occurs in Standley Lake. The Standley Lake maximum is approximately twice the maximum concentration for Great Western Reservoir and six times the maximum in Mower Reservoir. Although Mower Reservoir receives 100 percent of its water from

the RFP drainage, Mower Reservoir sediments have approximately half the lead concentration of Great Western Reservoir sediments and only 20 percent of the Standley Lake maximum sediment concentration. The likely source area for the lead in Standley Lake sediments is from the mining wastes being transported in Clear Creek. Only one sample (SED012792) from the 41 Great Western Reservoir samples exceeds the 95th percentile concentration (70 mg/kg) of the PROBPLOT-defined background population with a concentration of 80.3 mg/kg. This sample is located in the deepest portion of the reservoir. As described previously, the fine-grained sediments are transported to the deepest portion of the reservoir; this is probably why the concentration is higher. Contamination is not indicated because metals adsorb more readily to the finer-grained material (Davis and Kent, 1990, and Pankow, 1991).

A.4.10 Lithium

Based on probability plots, there is one population for lithium in all three reservoirs. Mean and median concentrations are highest in Mower, intermediate in Great Western, and lowest in Standley Lake. In all three, the median is higher than the mean lithium concentration; this indicates a dominance of lower lithium concentrations in all three populations. Similar to other metals, the maximum lithium concentration is highest in Standley Lake sediments. The maximum concentrations of lithium for Standley Lake, Great Western Reservoir, and Mower Reservoir are 34.6, 17.6 and 16.2 mg/kg, respectively. Lithium is a common constituent in micas, which are released by acid attack (mine waste areas) and, to a much lesser extent, natural weathering processes; ultimately, they are incorporated in the clay minerals (Deer et al., 1971). The maximum concentration occurring in Standley Lake is likely due to the contribution from the highly mineralized sediments from Clear Creek.

A.4.11 Manganese

One population for manganese was identified in Great Western Reservoir and Standley Lake from PROBPLOT for manganese. In Mower Reservoir, two similar populations were identified. The mean and medians for Great Western Reservoir (378.6 and 441.4 mg/kg, respectively) and Standley Lake (449.7 and 350.8 mg/kg, respectively) sediments are similar, but the maximum manganese concentration in Standley Lake (4450.4 mg/kg) sediments is three times higher than the maximum concentration in Great Western Reservoir (1549.9 mg/kg). This probably reflects the contribution from the highly mineralized Clear Creek sediments to Standley Lake. The mean, median, and maximum concentrations of manganese (294, 250.8, and 1170 mg/kg, respectively) are the lowest in Mower Reservoir.

The two subpopulation distributions in Mower Reservoir converge near the upper threshold concentration. The two subpopulations are likely due to fluctuations in pH within the reservoir. Of the three reservoirs, Mower Reservoir is the most strongly influenced by algal growth, which causes a diurnal (and seasonal) increase in pH to values above 9. Manganese precipitates much more rapidly with increasing pH, precipitating in minutes to hours at pH values higher than 8 (Stumm, 1990, and Pankow, 1991). This process increases the amount of oxidized manganese deposited in the reservoir sediments and causes variability in concentrations, depending on when the sampling occurred. In the other two reservoirs, manganese is also oxidized and precipitated, but the algal population is not sufficient to enhance the precipitation process. The two populations in Mower Reservoir are likely due to physical processes. The two subpopulations are similar to Standley Lake and Great Western Reservoir.

A.4.12 Mercury

Probability plots were only developed for Standley Lake. There was an insufficient number of detects to perform a PROBPLOT analysis for Great Western Reservoir and Mower Reservoir. One population was observed in Standley Lake based on the probability plot. The maximum mercury concentration in Standley Lake sediment is only 0.6 mg/kg. Considering the potential strong complexing characteristics (organics, microbiota, and chloride) of mercury and the placering (historical use of elemental mercury to recover gold) that has taken place along Clear Creek, these sediment concentrations of mercury are low.

A.4.13 Nickel

Based on the probability plots, one population for nickel was identified for each of the three reservoirs. The mean and median nickel concentrations in both Great Western Reservoir and Mower Reservoir are essentially the same values (16 to 17.5 mg/kg) and higher than Standley Lake sediment mean and median. The nickel is slightly higher in Mower Reservoir than in Great Western Reservoir; this difference may be due to the presence of aquatic microbiota.

Only one of the 41 Great Western sediment samples (SED00692) exceeds the 95th percentile concentration from PROBPLOT; the sample is located along Broomfield Ditch. This is the same location that has the highest concentrations for cobalt, manganese, and one of the highest concentrations for iron. This is the result of iron/manganese oxyhydroxide adsorption, which elevates the nickel and cobalt concentrations through the adsorption process (Davis and Kent, 1990; Pankow, 1991). This enhancement is most likely a natural phenomenon rather than an anthropogenic impact.

A.4.14 Silicon (Silica)

In Great Western Reservoir and Standley Lake, one population for silicon was identified, based on probability plots. In Mower Reservoir, only one sample was analyzed for silicon, so no PROBPLOT analysis was performed. The laboratory reports silica (SiO_2) in terms of Silicon, Si. Considering the abundance of silica in quartz and other minerals contained in sediments, the silica concentration is surprisingly low. The maximum concentrations of silica are less than 1 percent (10,000 mg/kg) compared to an average crustal abundance of approximately 28 percent (280,000 mg/kg) (Taylor, 1964). Standley Lake sediments have higher silica concentrations than Great Western, which probably reflects the higher quartz relative to mica in Standley Lake sediments. Quartz is readily available in the placer and mine waste areas of the Clear Creek drainage.

A.4.15 Zinc

One population for zinc was identified in each reservoir based on PROBPLOT. Zinc is one of the most mobile metals. The zinc mean, median, and maximum concentrations are all highest in Standley Lake (181.9, 184.4, and 1170 mg/kg, respectively) sediments, intermediate in Great Western Reservoir (137.8, 120.5, and 496 mg/kg, respectively), and lowest in Mower Reservoir (69.5, 68.6, and 193 mg/kg, respectively) sediments. These relationships support and enforce the relative importance of historic and current mining waste and discharge sources in the Clear Creek drainage to the site-specific background of Standley Lake sediments.

A.4.16 $^{239/240}\text{Pu}$

One population for $^{239/240}\text{Pu}$ was identified for Standley Lake and Great Western Reservoir. Two subpopulations were identified in Mower Reservoir. All activities in both Mower Reservoir and Standley Lake sediments are less than 1 pCi/g. Median activities and 95th percentile activity values from PROBPLOT indicate that Standley Lake sediments have the lowest activity, Mower Reservoir has intermediate activities, and Great Western Reservoir has the highest activities in sediments. In fact, three Great Western sediment samples (GWR-EG 46, 47, and 48) have the only activities that exceed 1 pCi/g across all three sediment reservoirs (3.1, 3.2, and 3.3 pCi/g, respectively). These three samples were collected in 1983 investigations. Given the two subpopulations in Mower Reservoir are similar to the values to the single populations in the other two IHSSs, it appears the activities represent background conditions. Further, the two subpopulations are converging, which indicates natural processes affecting one natural-background population.

74

A.4.17 $^{233/234}\text{U}$

Based on PROBPLOT, $^{233/234}\text{U}$ is remarkably consistent in all three reservoirs and shows only one population. The median activities for all three reservoirs are similar, ranging from 1.20 to 1.24 pCi/g. The 95th percentile activity values for Great Western and Mower are similar (2.79 and 2.61 pCi/g, respectively) but lower than Standley Lake sediment (3.71 pCi/g). The highest activity is in Great Western Reservoir (SED06692).

A.4.18 ^{235}U

Based on the PROBPLOT analysis, one population for ^{235}U was identified in each of the reservoirs. With the exception of a single exceedance from a sample in Great Western Reservoir (SED06692), described in the $^{233/234}\text{U}$ discussion, the ^{235}U activities are a background population. This single population is indicated by means, medians, and PROBPLOT 95th percentile activities. The suite of radioactivity present at SED06692 is likely due to natural uranium mineralization and not anthropogenic contamination.

A.4.19 Summary for Sediments

Most of the metals and radionuclides reviewed indicate the presence of only one population in a given reservoir. Where two subpopulations were identified, a review of the natural physical processes and associated physicochemical conditions indicates that the differences are due to natural environmental variability and not to contamination. As shown in Figure G-2, these chemicals exhibit two converging populations, unlike the diverging populations of the $^{239/240}\text{Pu}$ surface soil data.

REFERENCES

CDPHE, 1994. Colorado Department of Public Health and Environment. Health Studies on Rocky Flats. Phase I: Historical Public Exposures. Project Task 5 Report: Estimating Historical Emission from Rocky Flats 1952-1989. March 1994.

Davis and Kent, 1990. J.A. Davis and D.B. Kent. Surface Complexation Modeling in Aqueous Geochemistry. In: Mineral-Water Interface Geochemistry. M.F. Hochella, Jr., and A.F. White, eds. Mineralogical Society of America, *Reviews in Mineralogy*, Volume 23, pp. 177-260.

Deer et al., 1971. W.A. Deer, R.A. Howie, and V. Zussman. Rock Forming Minerals: Volume 3—Sheet Silicates. London: Longman, W. Clowes and Sons Limited.

DOE, 1994. United States Department of Energy. Lawrence Livermore National Laboratory Site 300 Remedial Investigation Report. 1994.

DOE, 1993. United States Department of Energy. Background Geochemical Characterization Report. September 30, 1993.

EPA, 1994. United States Environmental Protection Agency. Preliminary Draft. Operating Industries, Inc. Landfill Superfund Site. Monterey Park, California. May 1994.

Fletcher, 1986. W.K. Fletcher. Analysis of Soil Samples. In: Exploration Geochemistry: Design and Interpretation of Soil Surveys. Society of Economic Geologists, El Paso TX, pp. 79-96.

Hem, 1985. John D. Hem. Study and Interpretation of the Chemical Characteristics of Natural Water. U.S. Geological Survey. Water Supply Paper No. 2254.

Pankow, 1991. J.F. Pankow. Aquatic Chemistry Concepts. Chelsea, Michigan: Lewis Publishers.

Rose et al., 1979. A.W. Rose, H.E. Hawkins, and J.S. Webb. Geochemistry in Mineral Exploration. Second Edition. New York: Academic Press.

Schwoerbel, 1987. J. Schworbel. Handbook of Limnology. New York: John Wiley & Sons.

Sheridan et al., 1967. D.M. Sheridan, C.H. Maxwell, and A.L. Albee. Geology and Uranium Deposits of the Ralston Buttes District Jefferson County, Colorado. Geological Survey Professional Paper 520.

Sinclair, 1986. A.J. Sinclair. Statistical Interpretation of Soil Geochemical Data. In: Exploration Geochemistry: Design and Interpretation of Soil Surveys. Society of Economic Geologists, El Paso, TX, pp. 97-116.

Sinclair, 1976. A.J. Sinclair. Applications of Probability Graphs in Mineral Exploration. Association of Exploration Geochemists. Special Volume No. 4.

Stanley, 1987. C.R. Stanley. PROBPLOT: An Interactive Computer Program to Fit Mixtures of Normal (or Lognormal) Distributions with Maximum Likelihood Optimization Procedures. Association of Exploration Geochemists, Special Volume No. 14.

Stumm, 1990. Werner Stumm. Aquatic Chemical Kinetics, Reaction Rates of Processes in Natural Waters. New York: John Wiley & Sons, Inc.

Taylor, 1964. S.R. Taylor. Abundance of Chemical Elements in the Continental Crust: A New Table. *Geochimica et Cosmochimica Acta*, Vol. 28.

ARSENIC

IHSS 200, Great Western Reservoir

20:21:38

RFP / OU-3

05/08/94

SUMMARY STATISTICS and HISTOGRAM LOGARITHMIC VALUES

Variable =	As	Unit =	MG/K	N =	41
Mean =	0.6749	Min =	0.4150	1st Quartile =	0.5682
Std. Dev. =	0.1208	Max =	0.9731	Median =	0.6628
CV % =	17.8955	Skewness =	0.2745	3rd Quartile =	0.7442
Anti-Log Mean =		4.731	Anti-Log Std. Dev. : (-)		3.582
					(+) 6.247

=====					
%	cum %	antilog	cls int	(# of bins = 17 - bin size = 0.0349)	

0.00	1.19	2.498	0.3975		
2.44	3.57	2.707	0.4324	*	
0.00	3.57	2.933	0.4673		
2.44	5.95	3.178	0.5022	*	
4.88	10.71	3.444	0.5371	**	
17.07	27.38	3.732	0.5720	*****	
2.44	29.76	4.044	0.6068	*	
7.32	36.90	4.383	0.6417	***	
19.51	55.95	4.749	0.6766	*****	
4.88	60.71	5.146	0.7115	**	
12.20	72.62	5.577	0.7464	*****	
7.32	79.76	6.043	0.7813	***	
7.32	86.90	6.549	0.8161	***	
4.88	91.67	7.096	0.8510	**	
2.44	94.05	7.690	0.8859	*	
0.00	94.05	8.333	0.9208		
2.44	96.43	9.030	0.9557	*	
2.44	98.81	9.785	0.9906	*	

0 1 2 3 4

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20:22:07

05/08/94

RFP / DU-3

LOGARITHMIC VALUES

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VARIABLE = As

UNIT = MG/K

N = 41

N CI = 17

POPULATIONS

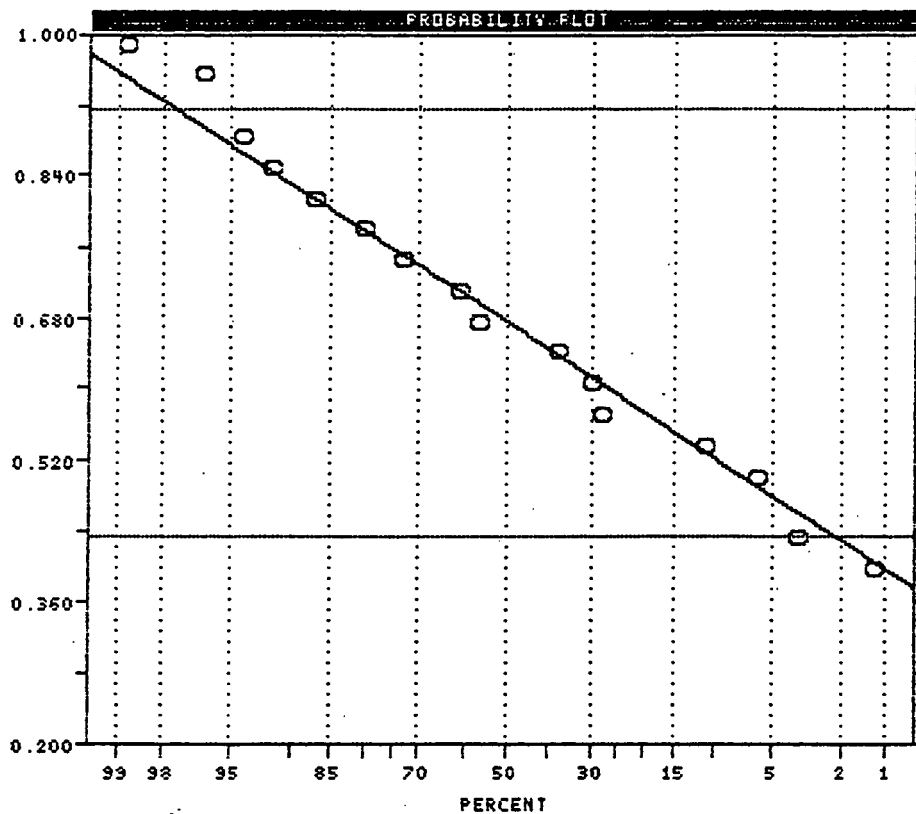
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Pop.	Mean	Std.Dev.	%
1	0.6749	0.1208	100.0

THRESHOLDS

=====

1	0.4334	0.9165
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RAW DATA ML
PARAMETER ESTIMATES

20:23:14

RFP / OU-3

05/08/94

PARAMETER SUMMARY STATISTICS FOR PROBABILITY PLOT ANALYSIS

Data File Name = AS-OD.DAT

Variable = As Unit = MG/K N = 41
N CI = 17

Transform = Logarithmic Number of Populations = 1

of Missing Observations = 0.

Raw Data Maximum Likelihood Parameter Estimates

Maximum LN Likelihood Value = 28.989

Parameterized Degrees of Freedom = 1

Population	Mean	Std Dev	Percentage
1	4.731	- 3.582 + 6.247	100.00

94

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3

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ARSENIC
IHSS 201, Standley Lake

1508

REF / 00-3

05/01/90

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##### LOGARITHMIC VALUES #####
SUMMARY STATISTICS and HISTOGRAM
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Variable ==	As	Unit ==	MG/K	N ==	47
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Mean ==	0.6962	Min ==	0.0792	1st Quartile ==	0.4191
Std. Dev. ==	0.2963	Max ==	1.2253	Median ==	0.7201
CV % ==	42.5597	Skewness ==	-0.3356	3rd Quartile ==	0.9457

Anti-Log Mean =	4.968	Anti-Log Std. Dev. :	(-)	2.511
			(+)	9.828

%	cum %	antilog	cls int	(# of bins = 17	bin size =	0.0716)
0.00	1.04	1.105	0.0434			
2.13	3.13	1.303	0.1150	*		
4.26	7.29	1.537	0.1866	**		
4.26	11.46	1.812	0.2583	**		
4.26	15.63	2.137	0.3299	**		
4.26	19.79	2.521	0.4015	**		
6.38	26.04	2.973	0.4732	***		
2.13	28.13	3.506	0.5448	*		
4.26	32.29	4.135	0.6164	**		
14.89	46.88	4.876	0.6881	*****		
14.89	61.46	5.750	0.7597	*****		
0.00	61.46	6.782	0.8313			
8.51	69.79	7.998	0.9030	***		
10.64	80.21	9.432	0.9746	*****		
4.26	84.37	11.123	1.0462	**		
12.77	96.87	13.118	1.1179	*****		
0.00	96.87	15.470	1.1895			
2.13	98.96	18.244	1.2611	*		

[illegible]

15:08:39

05/10/94

RFP / DU-3

LOGARITHMIC VALUES

=====

VARIABLE = AS

UNIT = MG/K

N = 47

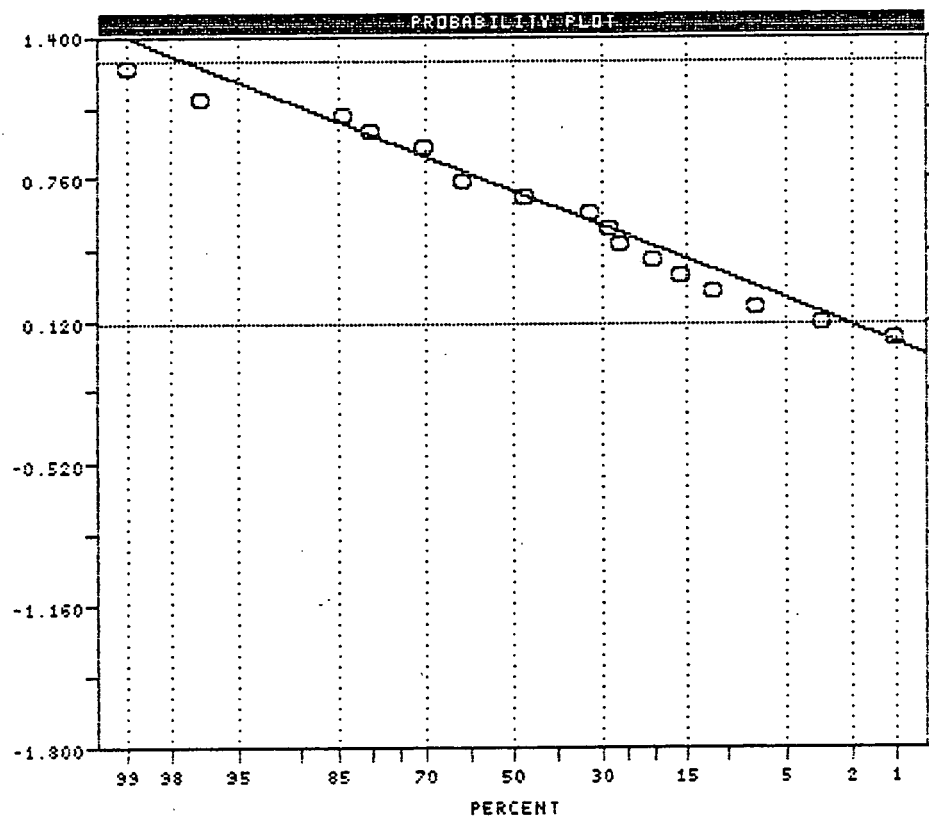
N CI = 17

POPULATIONS

=====

Pop.	Mean	Std.Dev.	%
1	0.6962	0.2963	100.0

Pop.	THRESHOLDS	
---	-----	
1	0.1036	1.2887



RAW DATA ML
PARAMETER ESTIMATES

15:11:37

RFP / OU-3

05/10/94

#####

PARAMETER SUMMARY STATISTICS FOR PROBABILITY PLOT ANALYSIS

Data File Name = AS-1D.DAT

Variable = As Unit = MG/K N = 47
 N CI = 17

Transform = Logarithmic Number of Populations = 1

of Missing Observations = 0.

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Raw Data Maximum Likelihood Parameter Estimates

Maximum LN Likelihood Value = -9.018

Parameterized Degrees of Freedom = 1

Population	Mean	Std Dev	Percentage
1	4.968	- 2.511	100.00
		+ 9.828	

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ARSENIC

IHSS 202, Mower Reservoir

11:09

RFP / DU-3: As-S

86
05/03/9

SUMMARY STATISTICS and HISTOGRAM LOGARITHMIC VALUE

Variable = As Unit = MG/K N = 18

Mean = 0.6793 Min = 0.3424 1st Quartile = 0.5623
 Std. Dev. = 0.1619 Max = 1.0170 Median = 0.7076
 CV % = 23.8314 Skewness = -0.2023 3rd Quartile = 0.7443

Anti-Log Mean = 4.778 Anti-Log Std. Dev. : (-) 3.292
 (+) 6.937

=====

%	cum %	antilog	cls int	(# of bins = 13 - bin size = 0.0562)
0.00	2.63	2.062	0.3143	
5.56	7.89	2.347	0.3705	*
0.00	7.89	2.671	0.4267	
11.11	18.42	3.041	0.4830	**
0.00	18.42	3.461	0.5392	
11.11	28.95	3.939	0.5954	**
5.56	34.21	4.484	0.6516	*
22.22	55.26	5.103	0.7078	****
22.22	76.32	5.808	0.7641	****
5.56	81.58	6.611	0.8203	*
11.11	92.11	7.525	0.8765	**
0.00	92.11	8.565	0.9327	
0.00	92.11	9.748	0.9889	
5.56	97.37	11.095	1.0451	*

0 1 2 3

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11:11:52

05/03/94

RFP / DU-3: As-S

LOGARITHMIC VALUES

=====

VARIABLE = As

UNIT = MG/K

N = 18

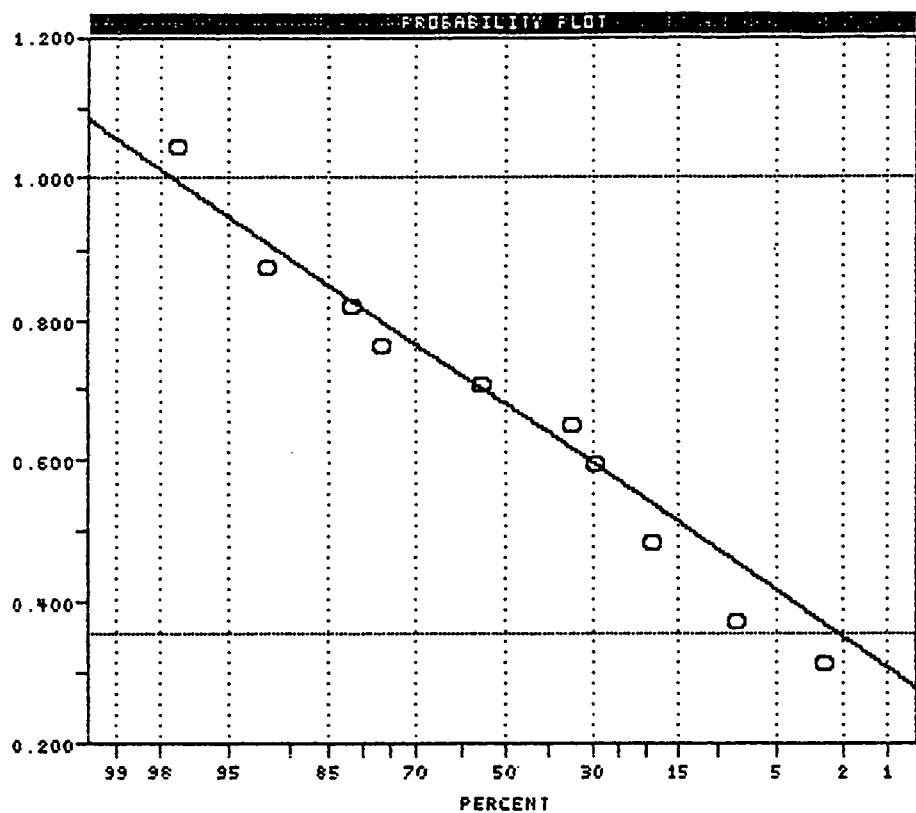
N CI = 13

POPULATIONS

=====

Pop.	Mean	Std.Dev.	%
1	0.6793	0.1619	100.0

Pop.	THRESHOLDS	
1	0.3555	1.0030



RAW DATA ML
PARAMETER ESTIMATES

11:12:44

RFP / OU-3: As-S

88
05/03/94

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PARAMETER SUMMARY STATISTICS FOR PROBABILITY PLOT ANALYSIS

Data File Name = A:AS-S.DAT

Variable = As Unit = MG/K N = 18
 N CI = 13

Transform = Logarithmic Number of Populations = 1

of Missing Observations = 0.

=====

Raw Data Maximum Likelihood Parameter Estimates

Maximum LN Likelihood Value = 7.735

Parameterized Degrees of Freedom = 1

Population	Mean	Std Dev	Percentage
-----	-----	-----	-----
1	4.778	- 3.292	100.00
		+ 6.937	

=====

Default Thresholds.

Standard Deviation Multiplier = 2.0

Pop.	Thresholds
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1	2.267 10.070

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BERYLLIUM

IHSS 200, Great Western Reservoir

ab

19:13:26 RFF / DU-3 05/08/94

***** SUMMARY STATISTICS and HISTOGRAM *****
LOGARITHMIC VALUES

Variable =	Be	Unit =	MS/K	N =	41
Mean =	-0.1044	Min =	-0.6198	1st Quartile =	-0.1973
Std. Dev. =	0.1636	Max =	0.2041	Median =	-0.0784
CV % =	156.7277	Skewness =	-0.8475	3rd Quartile =	0.0000
Anti-Log Mean =	0.786	Anti-Log Std. Dev. :	(-) 0.540	(+) 1.146	

%	cum %	antilog	cls int	(# of bins = 17 - bin size = 0.0515)
0.00	1.19	0.226	-0.6455	
2.44	3.57	0.255	-0.5940	*
0.00	3.57	0.287	-0.5425	
0.00	3.57	0.323	-0.4911	
0.00	3.57	0.363	-0.4396	
2.44	5.95	0.409	-0.3881	*
7.32	13.10	0.461	-0.3366	***
2.44	15.48	0.519	-0.2851	*
4.88	20.24	0.584	-0.2336	**
7.32	27.38	0.658	-0.1821	***
12.20	39.29	0.740	-0.1306	****
9.76	48.81	0.833	-0.0791	****
9.76	58.33	0.938	-0.0276	****
26.83	84.52	1.057	0.0239	*****
2.44	86.90	1.190	0.0754	*
7.32	94.05	1.339	0.1269	***
2.44	96.43	1.508	0.1784	*
2.44	98.81	1.698	0.2299	*

19:16:55

05/08/94

RFP / DU-3

LOGARITHMIC VALUES

=====

VARIABLE = Be

UNIT = MG/K

N = 41

N CI = 17

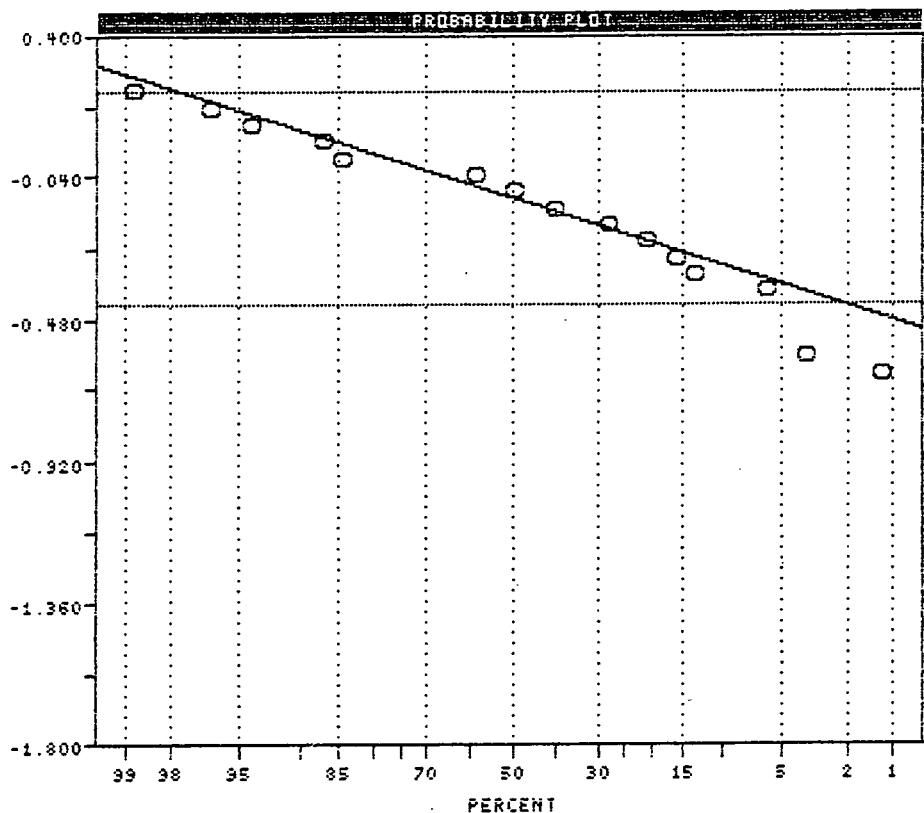
POPULATIONS

=====

Pop.	Mean	Std.Dev.	%
1	-0.1044	0.1636	100.0

POP. THRESHOLDS

Pop.	Mean	Std.Dev.
1	-0.4316	0.2228



RAW DATA ML
PARAMETER ESTIMATES

19:18:08

RFP / OU-3

05/08/94

PARAMETER SUMMARY STATISTICS FOR PROBABILITY PLOT ANALYSIS

Data File Name = BE-OD.DAT

Variable = Be Unit = MG/K N = 41
N CI = 17

Transform = Logarithmic Number of Populations = 1

of Missing Observations = 0.

Raw Data Maximum Likelihood Parameter Estimates

Maximum LN Likelihood Value = 16.550

Parameterized Degrees of Freedom = 1

Population	Mean	Std Dev	Percentage
1	0.786	0.540	100.00
		1.146	

BERYLLIUM

IHSS 201, Standley Lake

04

14:13:03

RFP / OU-3

05/10/94

SUMMARY STATISTICS and HISTOGRAM
LOGARITHMIC VALUES

Variable = Be Unit = MG/K N = 43

Mean = -0.2271 Min = -0.8239 1st Quartile = -0.4593
Std. Dev. = 0.2637 Max = 0.2041 Median = -0.2244
CV % = 116.1341 Skewness = -0.2077 3rd Quartile = -0.0114

Anti-Log Mean = 0.593 Anti-Log Std. Dev. : (-) 0.323
(+) 1.088

% cum %		antilog	cls int	(# of bins = 17	bin size = 0.0643)
0.00	1.14	0.139	-0.8560		
2.33	3.41	0.162	-0.7918	*	
2.33	5.68	0.187	-0.7275	*	
0.00	5.68	0.217	-0.6633		
4.65	10.23	0.252	-0.5990	**	
2.33	12.50	0.292	-0.5348	*	
9.30	21.59	0.338	-0.4705	***	
4.65	26.14	0.392	-0.4063	**	
11.63	37.50	0.455	-0.3420	*****	
2.33	39.77	0.528	-0.2778	*	
9.30	48.86	0.612	-0.2135	***	
11.63	60.23	0.709	-0.1493	*****	
6.98	67.05	0.822	-0.0850	***	
6.98	73.86	0.953	-0.0208	***	
11.63	85.23	1.105	0.0435	*****	
0.00	85.23	1.282	0.1077		
6.98	92.05	1.486	0.1720	***	
6.98	98.86	1.723	0.2362	***	

0 1 2 3 4

#####

14:14:22
05/10/94

RFP / DU-3

LOGARITHMIC VALUES

=====

VARIABLE = Be
UNIT = MG/K
N = 43
N CI = 17

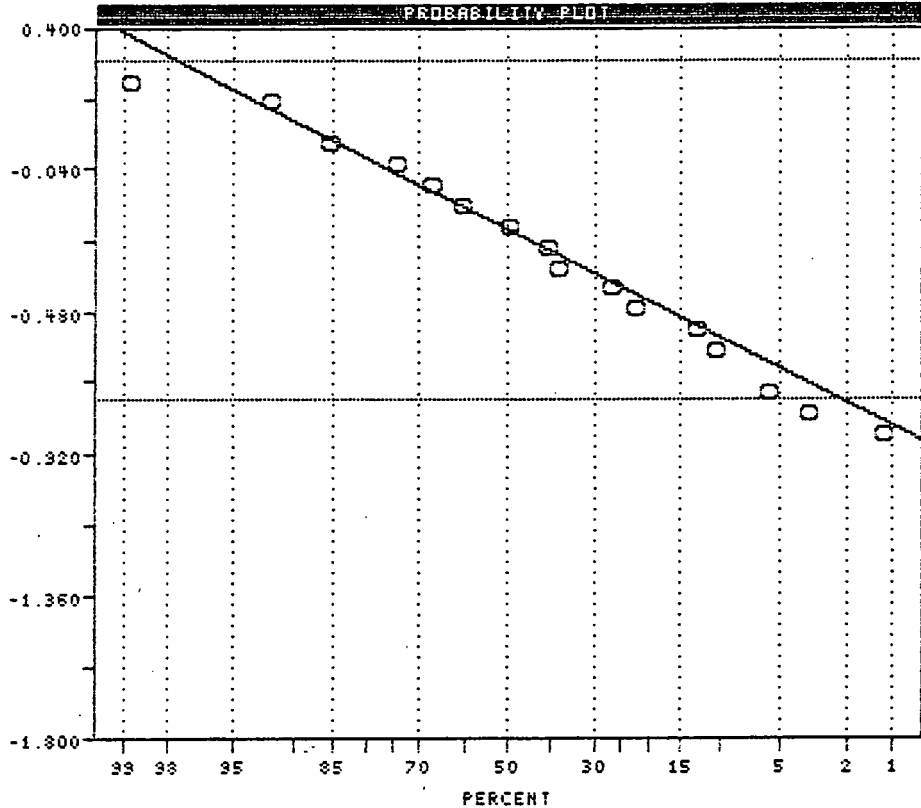
POPULATIONS

=====

Pop.	Mean	Std.Dev.	%
1	-0.2271	0.2637	100.0

Pop.	THRESHOLDS	
1	-0.7546	0.3004

RAW DATA ML
PARAMETER ESTIMATES



14:15:31

RFP / OU-3

05/10/94

#####

PARAMETER SUMMARY STATISTICS FOR PROBABILITY PLOT ANALYSIS

Data File Name = BE-1D.DAT

Variable =	Be	Unit =	MG/K	N =	43
				N CI =	17

Transform = Logarithmic Number of Populations = 1

of Missing Observations = 0.

=====

Raw Data Maximum Likelihood Parameter Estimates

Maximum LN Likelihood Value = -3.205

Parameterized Degrees of Freedom = 1

Population	Mean	Std Dev	Percentage
-----	-----	-----	-----
1	0.593	0.323	100.00
	+	1.088	

#####

BERYLLIUM

IHSS 202, Mower Reservoir

13:44:09

RFP / DU-3: Be-S

98
06/24/94

SUMMARY STATISTICS and HISTOGRAM LOGARITHMIC VALUES

Variable = Be Unit = MG/K N = 16

Mean = -0.0217 Min = -0.3872 1st Quartile = -0.0862
 Std. Dev. = 0.1683 Max = 0.1761 Median = 0.0414
 CV % = 773.9253 Skewness = -0.7923 3rd Quartile = 0.1139

Anti-Log Mean = 0.951 Anti-Log Std. Dev. : (-) 0.646
 (+) 1.401

=====					
%	cum %	antilog	cls int	(# of bins = 13 - bin size = 0.0469)	

0.00	2.94	0.388	-0.4107		
6.25	8.82	0.433	-0.3637	*	
0.00	8.82	0.482	-0.3168		
0.00	8.82	0.537	-0.2699		
12.50	20.59	0.599	-0.2229	**	
0.00	20.59	0.667	-0.1760		
6.25	26.47	0.743	-0.1290	*	
6.25	32.35	0.828	-0.0821	*	
0.00	32.35	0.922	-0.0351		
18.75	50.00	1.028	0.0118	***	
18.75	67.65	1.145	0.0587	***	
6.25	73.53	1.275	0.1057	*	
12.50	85.29	1.421	0.1526	**	
12.50	97.06	1.583	0.1996	**	

			0	1	2 3 4

#####

13:45:32

RFP / OU-3: Be-S

06/24/94

#####

PARAMETER SUMMARY STATISTICS FOR PROBABILITY PLOT ANALYSIS

Data File Name = A:BE-S.DAT

Variable = Be Unit = MG/K N = 16
N CI = 13

Transform = Logarithmic Number of Populations = 1

of Missing Observations = 0.

=====

Raw Data Maximum Likelihood Parameter Estimates

Maximum LN Likelihood Value = 6.311

Parameterized Degrees of Freedom = 1

Population	Mean	Std Dev	Percentage
1	0.951	- 0.646 + 1.401	100.00

=====

Default Thresholds.

Standard Deviation Multiplier = 2.0

Pop.	Thresholds
1	0.438 - 2.065

#####

13:46:10
06/24/94

RFP / DU-3: Be-5

LOGARITHMIC VALUES

=====

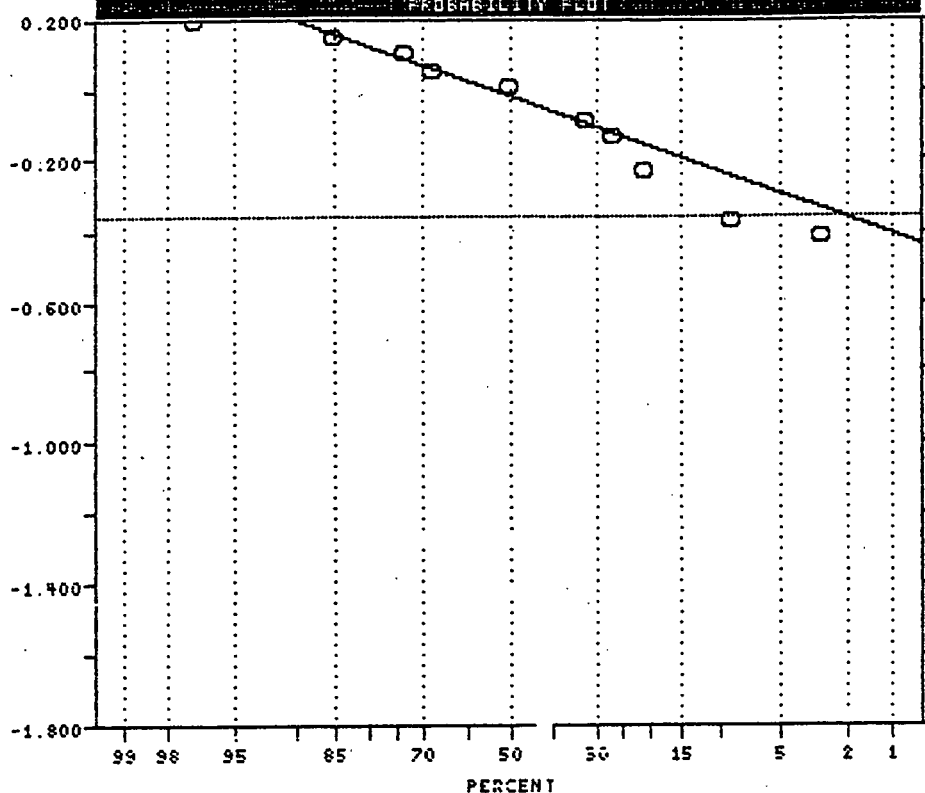
VARIABLE = Be
UNIT = MG/K
N = 16
N CI = 13

POPULATIONS

=====

Pop.	Mean	Std.Dev.	%
1	-0.0217	0.1683	100.0

Pop.	THRESHOLDS
1	-0.3583 0.3198



RAW DATA ML
PARAMETER ESTIMATES

ROCKY FLATS PROJECT NO. RME70414

OU 3 RFI/RI

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(information 966-7000)

Fax/Courier

☐ Mark Buddy
 966-8519 FAX: 966-8556
☐ Mary Siders
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☐ Rick Roberts
 966-8508 FAX 966-8663

☐ Tracey Spence
 966-8551 FAX 966-8556
☐ Holly Wolaver
 966-8652

RA Consultants:

Fax/Courier

☐ Sam Bamberg
☐ Ingrid Hanne
 690-7402 FAX 680-9203

Aguirre

Fax/Courier

☐ Michael Guillaume
 966-4208 FAX 966-4871

DOE:

Mail/Courier

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